HIWIN®

Motion Control and System Technology

D2 Drive User's Manual

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Version	Date	Applicability	Remarks
1.0	2012-01-10	D2 Motor Drive	Initial edition
1.1	2012-04-10	D2 Motor Drive	Revision

1 About the Operation Manual

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1.1 Instructions before use

Read the Operation Manual carefully before using the product. mega-fabs Motion System ('the Company') will not take any responsibility for damage, accidents or injuries caused by installation or use that is not performed according to these instructions.

◆ Do not dismantle or modify the product. The product has been subject to structural calculations, computer simulation and physical testing to verify its design. Do not dismantle or modify the product without the consent of the Company's professional technicians. The Company does not take any responsibility for accidents or damage resulting from such dismantling or modifications.

◆ Before installing or using the product, check the external appearance and ensure there is no damage on the surface of the product. If any damage is identified, please contact the Company or one of the Company's dealers immediately.

◆ Please refer to the performance specifications on the product label or manufacturer's document before using the product. Only install the product with reference to these performance limits and in accordance with the installation instructions.

◆ Please read the power voltage specifications and labeling before using the product and confirm that the power supply to be used meets the product requirements. The Company does not take any responsibility for product damage or personal injury resulting from incorrect power use.

◆ Do not use the product over the rated load. The Company does not take any responsibility for damage or injury caused by such misuse of the product.

◆ Do not use the product in an environment where shocks may occur. The company does not take any responsibility for damage, accidents or injuries of any kind attributable to such shocks.

◆ Do not try to repair any product malfunctions. The product can only be repaired by qualified technicians.

The warranty period is one year from the ex-factory date. The Company does not take any responsibility for product replacement or repair caused by inappropriate use or natural disasters. (Please refer to the notes and installation instructions in the Operation Manual.)

1.2 Safety instructions

◆ Please read this Operation Manual carefully before installation, transportation, maintenance and inspection, and ensure the product is used appropriately.

◆ Users should read the EM information, safety information, and all related instructions before using the product.

◆ The safety instructions in the Operation Manual are categorized under the "Warning", "Attention", "Prohibited" and "Required" sections.

⚠ Warning

Inappropriate operation may bring about danger or result in serious injury or death.
Inappropriate operation may bring about disability, light injury or material damage.

⚠ Attention

Actions marked **⚠ Attention** may have a serious consequence. All such instructions are important and must be followed.

Prohibited

Indicates that the action is forbidden and must not be done.

Required

Indicates that the action is compulsory and must be done.

◆ Usage instructions

Warning

1. Do not touch the terminal or the inside of the product when it is powered in order to avoid electric shock.
2. Do not cut the cable, apply too much stress to it, or place heavy objects on it. Laying the cable between objects may increase the risk of fire or electric shock.

Attention

1. Do not install the product in a place exposed to moisture or erosion, or in an environment containing ignitable gas. Do not use the product close to any flammable objects.

◆ Storage

Prohibited

1. Do not store the product in a place exposed to water, moisture, direct sunlight, or harmful gas or liquids.

◆ Handling

Attention

1. Be careful when handling the product to avoid damage.
2. Use appropriate handling methods and do not apply too much pressure to the case.
3. The product shall not be stacked to avoid instability or collapse.

◆ Installation location

Required

1. The product shall not be installed in a place exposed to high temperatures, high humidity, or flying dust, iron powder or metal fragments.
2. Install the product in a place where the ambient temperature meets the requirements of the Operation Manual. Use a cooling fan in case of potential high temperatures.
3. Do not install the product in a place exposed to direct sunlight.
4. Since the product does not have a waterproof or moisture-proof case, do not use it outdoors or install it in a place where water or other liquids exist.
5. Install the product in a place vibrations are as low as possible.
6. Depending on the frequency of use, heat is generated when the motor is used continuously. Use a cooling fan, or set the product to standby if it stops, in order to lower the ambient temperature of the product so it does not exceed the specified value.

◆ Installation

Attention

1. Do not place any heavy objects on the product to avoid damage.
2. Do not mix with foreign matter or debris to avoid fire.
3. Ensure that the product is oriented and installed in the specified direction to avoid fire.
4. Protect the product from high impact shocks to avoid damage or injury.
5. The product weight must be taken into account during installation. Inappropriate installation may cause damage or injury.
6. Install the product on a metal or similar noncombustible rack to avoid fire.

◆ Wiring

Attention

1. Correct and reliable wiring must be used to ensure stable operation and avoid damage, fire or injury.

◆ Operation and transportation

Attention

1. Ensure the power source specifications are correct to avoid fire or injury.
2. The product may restart suddenly after power is restored. Do not come too close to the product.

Required

1. An external emergency stop line must be wired to cut power and stop the product at any time.

◆ Maintenance

Prohibited

1. Do not dismantle or modify the product.
2. Do not attempt to repair any product malfunction. Instead, send the product back to the Company's professional technicians for repair.

2. Overview of the Specifications

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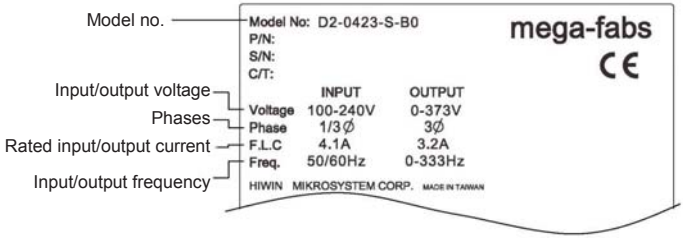
2.1 Safety certification

The product complies with the requirements of the following safety standards.

CE Compliance

EMC	EN55011
	EN61000-6-2
	EN61800-3
LVD	EB61800-5-1

2.1.1 Nameplate information



2.1.2 Model number

Column	1	2	3	4	5	6	7	8	9	10	11	12
Example	D	2	-	0	4	2	3	-	S	-	B	0

Item number
D2 drive ····· =D2

Rated output
50W/100W ····· =01
200W/400W ····· =04
750W/1000W ····· =10

AC voltage
Single-phase ····· =1
Three-phase ····· =2

AC voltage range
110V/220V ····· =3

Control interface
Pulse type (for position control) ····· =P
Full function ····· =S

Frame
A Frame ····· =A
B Frame ····· =B
C Frame ····· =C

Encoder type
13-bit standard and wiring-saving incremental encoders ····· =0
17-bit serial incremental encoder ····· =4

2.2 Servo drive specifications

2.2.1 Servo drive specifications (full function)

Basic specifications	Power input	220V	Main power	A-C Frames	Single/three-phase, 200-240V 50/60Hz
			Control power	A-C Frames	Single-phase, 200-240V 50/60Hz
	Ambient conditions		Temperature		Operating temperature: 0-45°C (Air circulation must be available when the ambient temperature is higher than 55°C) Storage temperature: -20℃ to +65℃
			Humidity		0 to 90% RH (non-condensing)
			Altitude		Elevation less than 1,000 meters
			Protection against vibration		1G (10-500Hz)
	Main circuit control mode				IGBT PWM space vector control
	Encoder/feedback resolution				13-bit (10,000 count/rev) standard incremental encoder (9-line) and wiring-saving incremental encoder 17-bit (131,072 count/rev) serial incremental encoder (5-line)
	I/O signal connector	Control signal		Input	9 (general purpose)
				Output	4 (general purpose)
		Analog signal		Input	1 (12-bit A/D)
				Output	2 (analog monitoring: 2 outputs)
		Pulse signal		Input	2 (low-speed channel, high-speed channel)
				Output	4 (differential line driver with 3 outputs; open collector with 1 output)
	Brake connector	Control signal		Output	Used for direct connection to the brake. It can also be used for programmable general purpose output.
	Communication function			USB	For PC connection, 115,200 bps
	Panel/indicator				4-key, dot-matrix, 8*2 character LCD status display with LED status indicator (green/red)
	Regenerative function				External connection is needed as no built-in regenerative resistor is available
	Control mode				The control mode is switchable: (1) Position mode (2) Velocity mode (3) Torque mode (4) Position/velocity mode (5) Position/torque mode (6) Velocity/torque mode
Function specifications	Position control mode	Control input			(1) Pulse inhibit command (2) Clear position error (3) Servo on (4) Switch between first and second gain (5) Electronic gear ratio selection (6) Left limit switch (7) Switch between primary and secondary mode (8) Clear error (9) Right limit switch etc.
		Control output			(1) Servo ready (2) Error (3) In-position output (4) Zero speed detection
		Pulse input	Maximum input pulse frequency		For optical coupler interface (single-ended input): 500 kpps For line driver interface (differential input): 4 Mpps (16M cnt/s at AqB)
			Input pulse signal format		(1) Pulse/direction (Pulse/Dir) (2) Clockwise/counterclockwise (CW/CCW) (3) A/B phase (AqB)
			Electronic gear		Gear ratio: pulses/counts Pulses: 1-2147483647; counts: 1-2147483647
			Smoothing filter		Smoothing filter coefficient: 1-500 (0: no smoothing filter)

		Vibration suppression function (VSF)		VSF can eliminate vibration frequency during motion and suppress vibrations generated due to the system structure to improve the machine productivity
	Velocity control mode	Control input		(1) Zero speed clamp (2) Servo on (3) Switch between first and second gain (4) Left limit switch (5) Switch between primary and secondary mode (6) Clear error (7) Right limit switch etc.
		Control output		(1) Servo ready (2) Error (3) In-speed output (4) Zero speed detection.
		PWM input	Velocity command input	The velocity command can be provided via the PWM input duty cycle. Parameters can be set for the ratio and command direction.
		Analog input	Velocity command input	The velocity command can be provided via the analog voltage. Parameters can be set for the ratio and command direction.
		Zero speed clamp		Zero speed clamp input is possible
	Torque control mode	Control input		(1) Servo on (2) Switch between first and second gain (3) Left limit switch (4) Switch between primary and secondary mode (5) Clear error (6) Right limit switch etc.
		Control output		(1) Servo ready (2) Error (3) In-speed output (4) Zero speed detection
		PWM input	Torque command input	The torque command can be provided via the PWM input duty cycle. Parameters can be set for the ratio and command direction.
		Analog input	Torque command input	The torque command can be provided via the analog voltage. Parameters can be set for the ratio and command direction.
		Velocity limitation function		Setting the velocity limitation is possible.
	Common	Auto tune		The auto tune procedure starts automatically after execution. The load inertia is automatically determined without the need to set it manually. All required gain values are set using a key on the LCD display.
		Emulated encoder output		Can be set freely (maximum frequency 18M cnt/s)
		Protection function		(1) Motor short circuit detection (2) Overvoltage (3) Position error too big (4) Encoder error (5) Soft thermal protection (6) Motor disconnection detection (7) Amplifier overheating (8) Under voltage (9) Abnormal 5V encoder power source (10) Phase initialization error (11) Abnormal serial encoder communication
		Error log feature		Errors and warnings can be logged and reviewed
		Error mapping		Method: Establish error mapping using linear interpolation encoder error compensation
				Sampling: maximum 16,000 points
				Storage: Flash ROM; hard drive file
				Unit: um, count
				Activation: After internal homing or activated by external input signal
		Miscellany		Friction compensation, backlash compensation

2.2. Servo drive specifications (pulse type)

Basic specifications	Power input	220V	Main power	A-B Frames	Single-phase, 200-240V 50/60Hz
				C Frame	Single/three-phase, 200-240V 50/60Hz
			Control Power	A-C Frames	Single-phase, 200-240V 50/60Hz
	Ambient conditions		Temperature		Operating temperature: 0-45°C (Air circulation must be available when the ambient temperature is higher than 55°C) Storage temperature: -20°C to +65°C
			Humidity		0 to 90% RH (non-condensing)
			Altitude		Elevation less than 1,000 meters
			Protection against vibration		1G (10-500Hz)
	Main circuit control mode				IGBT PWM space vector control
	Encoder/feedback resolution				13-bit (10,000 count/rev) standard incremental encoder (9-line) and wiring-saving incremental encoder 17-bit (131,072 count/rev) serial incremental encoder (5-line)
	I/O signal connector	Control signal		Input	9 (general purpose)
				Output	4 (general purpose)
		Pulse signal		Input	2 (low-speed channel, high-speed channel)
				Output	4 (differential line driver with 3 outputs; open collector drive with 1 output)
	Brake connector	Control signal		Output	Used for direct connection to the brake. It can also be used for programmable general purpose output.
	Communication function			USB	For PC connection, 115,200 bps
	Panel/indicator				4-key, dot-matrix, 8*2 character LCD status display With LED status indicator (green/red)
	Regenerative function				External connection is needed as no built-in regenerative resistor is available
	Control mode				Position mode
Function specifications	Position control mode	Control input			(1) Pulse inhibit command (2) Clear position error (3) Servo on (4) Switch between first and second gain (5) Electronic gear ratio selection (6) Left limit switch (7) Switch between primary and secondary mode (8) Clear error (9) Right limit switch etc.
		Control output			(1) Servo ready (2) Error (3) In-position output (4) Zero speed detection.
		Pulse input	Maximum input pulse frequency		For optical coupler interface (single-ended input): 500 kpps For line driver interface (differential input): 4 Mpps (16M cnt/s at AqB)
			Input pulse signal format		(1) Pulse/direction (Pulse/Dir) (2) Clockwise/counterclockwise (CW/CCW) (3) A/B phase (AqB)
			Electronic gear		Gear ratio: pulses/counts Pulses: 1-2147483647; counts: 1-2147483647
			Smoothing filter		Smoothing filter coefficient: 1-500 (0: no smoothing filter)
		Vibration suppression function (VSF)			VSF can eliminate vibration frequency during motion and suppress vibrations generated due to the system structure to improve the machine productivity

	Common	Auto tune	The auto tune procedure starts automatically after execution. The load inertia is automatically determined without the need to set it manually. All required gain values are set using a key on the LCD display.
		Emulated encoder output	Can be set freely (maximum frequency 18M cnt/s)
		Protection function	(1) Motor short circuit detection (2) Overvoltage (3) Position error too big (4) Encoder error (5) Soft thermal protection (6) Motor disconnection detection (7) Amplifier overheating (8) Under voltage (9) Abnormal 5V encoder power source (10)Phase initialization error (11) Abnormal serial encoder communication
		Error log feature	Errors and warnings can be logged and reviewed
		Error mapping	Method: Establish error mapping using linear interpolation encoder error compensation
			Sampling: maximum 16,000 points
			Storage: Flash ROM; hard drive file
			Unit: um, count
			Activation: After internal homing or activated by external input signal
		Miscellany	Friction compensation, backlash compensation

2.3 Dimensions of the drive

The drive dimensions and location of the holes are shown in the following figures. The dimension units are in mm and the diameter of the mounting hole is 4 mm.

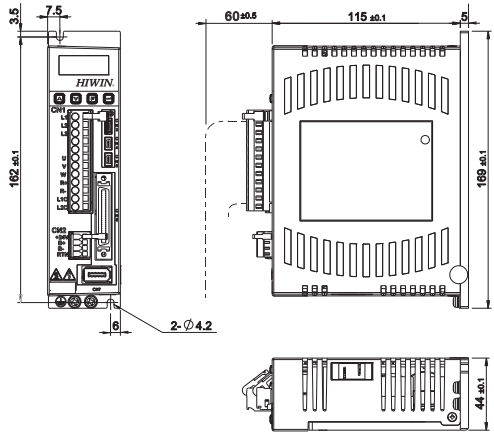


Fig. 2-1 A Frame dimensions

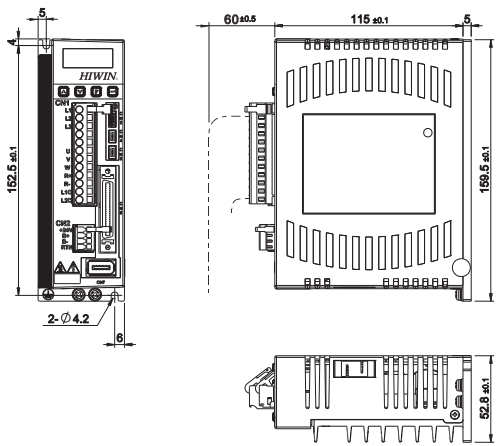


Fig. 2-2 B Frame dimensions

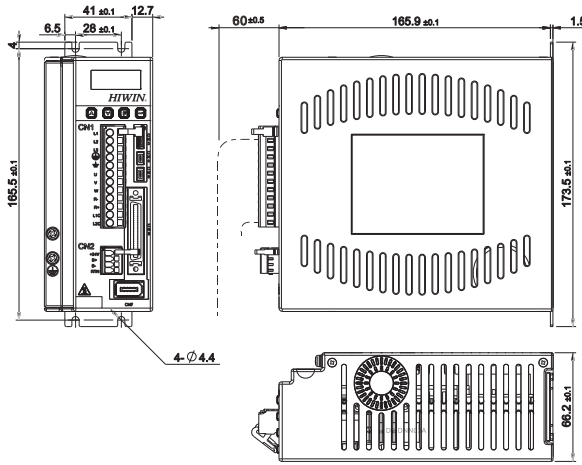


Fig. 2-3 C Frame dimensions

2.4 Installation of the drive

Fix the drive in the electric cabinet using conductive screws. All insulating materials on the contact surface of the cabinet must be thoroughly removed so that the drive can connect to the ground through the machine. The ground resistance must be less than 50Ω at 220V and less than 100Ω at 110V.

If more than one drive is installed, a distance of more than 20 mm must be maintained between the drives to ensure heat dissipation. Fans can be attached to the electric cabinet to facilitate heat dissipation.

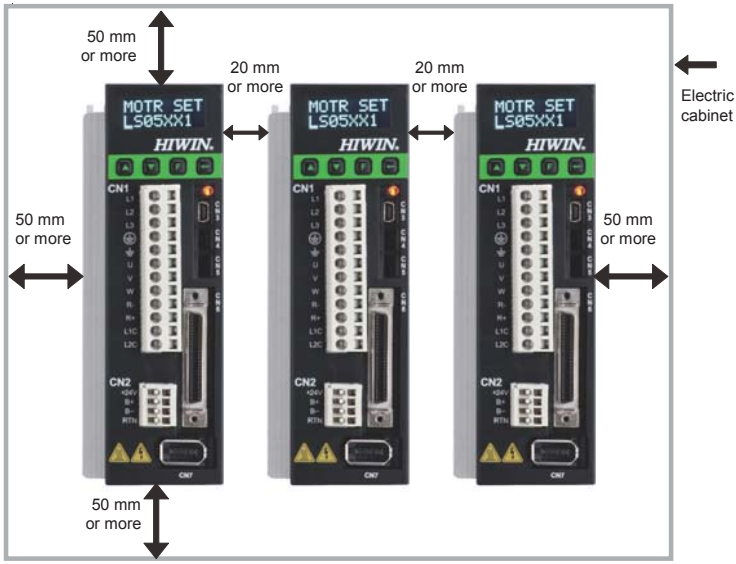


Fig. 2-4 Distance between drives

2.5 Computer requirements

CPU	1.0 GHz or better
RAM	512 MB or more
Hard drive space	50 MB or more
Communication port	USB
Operating system	Windows 2000, Windows XP, Windows 7
Screen resolution	1024x768 pixels or more

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3.1 System configuration and wiring

This chapter introduces the drive configuration and functions of each parts. Following figure is showing the details of drive configuration.

3.1.1 Master wiring diagram

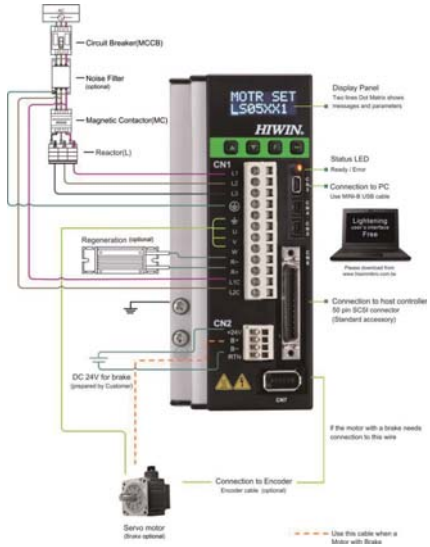


Fig. 3-1

Table 3-1

Item no.	Name	Description
①	AC main power cable (CN1)	L1, L2: Single-phase 110-240V AC, 50/60Hz L1, L2, L3: Three-phase 200-240V AC, 50/60Hz
②	Motor power cable (CN1)	Connection to motor, three-phase motor power (⏚, U, V, W)
③	Regenerative resistor (CN1)	Connection to motor regenerative resistor (optional/mounted according to actual application design) (REG-/REG+)
④	Control power cable (CN1)	For drive internal control and IO power (L1C, L2C) L1C, L2C: Single-phase 110-240V AC, 50/60Hz
⑤	Brake (CN2)	Connection to brake (optional/mounted according to actual application design)
⑥	Mini USB communication (CN3)	Connection to PC (for setting parameters; to be removed after setting) Mini USB and the PC are used as links for monitoring, drive test runs, or writing parameters
⑦	Control signal (CN6)	Connection to the host controller
⑧	Feedback signal (CN7)	Connection to the motor encoder

3.1.2 CN1 power connector

Ensure that the drive has been grounded appropriately before connecting the drive to the main circuit.

The CN1 power wiring description includes single/three-phase power input, motor power output, single-phase control power input, and regenerative resistor wiring.

3.1.2.1 CN1 connector

For D2-xxxx-x-B(F)

Connector to the extended line: Wago 2092-1112 (female)

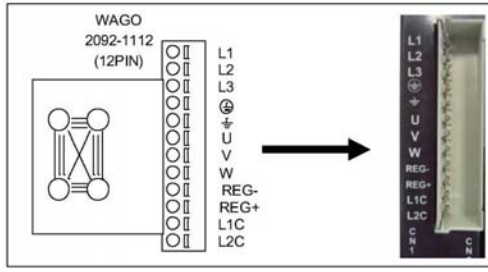


Fig. 3-2 CN1 connector

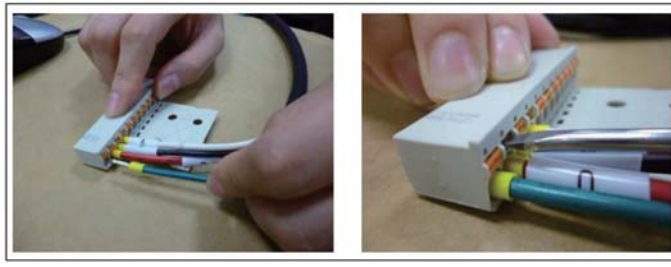


Fig. 3-3 CN1 installation and removal steps

For D2-xxxx-x-B (G) and D2-xxxx-x-B0
Connector to the extended line: Wago 721-112/026-000 (female)

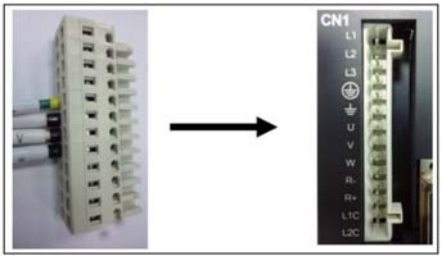


Fig. 3-4 CN1 connector

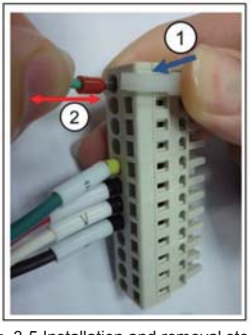


Fig. 3-5 Installation and removal steps

3.1.3 Motor wiring diagram

Well grounding is needed between the drive and the motor.

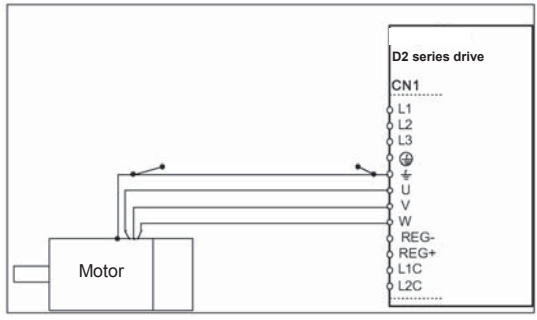


Fig. 3-6

3.1.4 Regenerative resistor (optional) wiring diagram

The regenerative resistor is mounted optionally according to the actual application design.

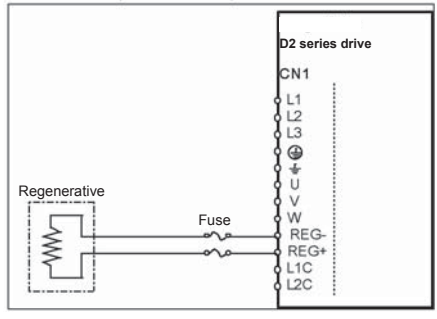


Fig. 3-7

⚠ Attention

- **Wiring and inspection must be conducted by professional technicians.**
- **Turn off the power before wiring or inspection to avoid electric shock and other dangers.**
- **High voltage may remain in the drive after the power is turned off. Wait for a while (up to five minutes) before touching the power terminal.**
- **Perform the wiring appropriately and reliably to ensure stable operation and avoid injury, damage or other accidents.**
- **Do not connect the motor U, V or W terminal to the power source.**
- **The motor power terminal must be securely connected to the power source to avoid fire.**
- **Ensure that the drive and motor are grounded appropriately.**
- **Wiring must be conducted after installation of the drive and motor to avoid electric shock.**
- **Do not damage, pull or squeeze the wire so as to avoid electric shock.**
- **The drive may interfere with the operation of nearby electronic equipment. A noise filter can be used to reduce such electromagnetic interference.**
- **Do not attempt to modify the drive.**
- **Do not put the main circuit cable, I/O signal cable, or encoder cable in the same duct or bind them together. A distance of more than 30 cm must be maintained between the cables.**
- **The following instructions must be observed for wiring the main circuit terminals:**
  - ※ Do not insert more than one wire in the same socket.
  - ※ Check there is no short circuit with any nearby wires after inserting the wire.
  - ※ Ensure the specified power voltage is used to avoid fire or damage.
- **If the drive is to be used under poor or significantly fluctuating power conditions, ensure power is supplied within the specified voltage fluctuation range so as to avoid damage.**
- **Install a breaker or other safety devices to prevent external short circuits from damaging the drive.**
- **Appropriate isolating and sheltering measures must be taken if the drive is used in the following places to avoid adverse operation.**
  - ※ Places exposed to static interference.
  - ※ Places exposed to strong electrical or magnetic fields.
  - ※ Places exposed to radiation.

3.1.5 CN2 brake connector

The brake can be wired with or without a relay. Refer to the wiring diagram for connection to the 24V DC brake.

3.1.5.1 CN2 connector

For D2-xxxx-x-B (G) and D2-xxxx-x-B (F)
Connector to the line: WAGO 733-103

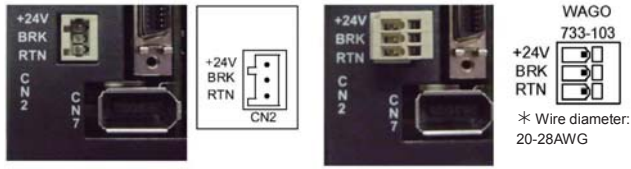


Fig. 3-8

For D2-xxxx-x-B0
Connector to the line: WAGO 734-104

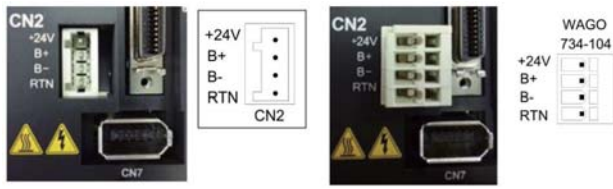


Fig. 3-9

3.1.5.2 Brake wiring with a relay

For D2-xxxx-x-B(G) and D2-xxxx-x-B(F)

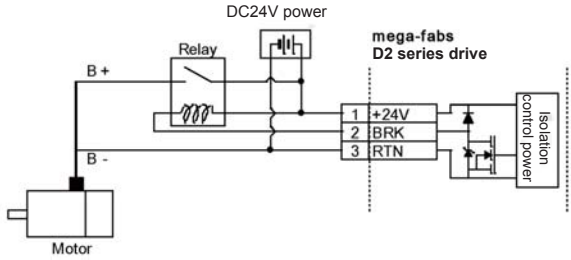


Fig. 3-10 Brake wiring with a relay for D2-xxxx-x- B(G) and D2-xxxx-x-B(F)

For D2-xxxx-x-B0

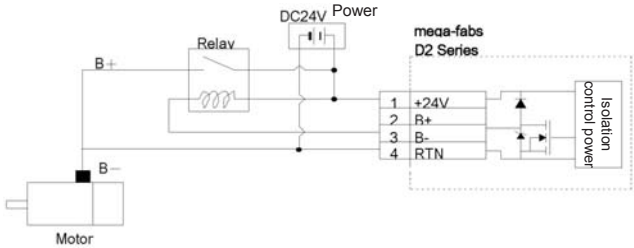


Fig. 3-11 Brake wiring with a relay for D2-xxxx-x-B0

3.1.5.3 Brake wiring without a relay

Direct mounting to the HIWIN motor is allowed.

For D2-xxxx-x-B(G) and D2-xxxx-x-B(F)

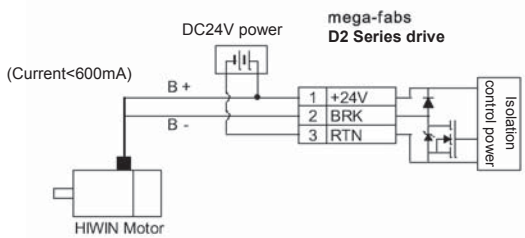


Fig. 3-12 Brake wiring without a relay for D2-xxxx-x-B(G) and D2-xxxx-x-B(F)

For D2-xxxx-x-0

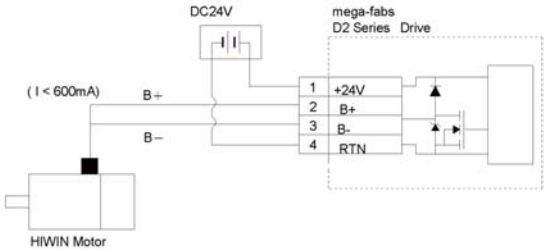


Fig. 3-13 Brake wiring without a relay for D2-xxxx-x-0

For wiring without a relay, the dynamic or electromagnetic brake on the motor is activated directly using the open-drain switch on D2. The brake output BRK is open drain and can sustain a maximum of 40V voltage and 1A current. Use this in conjunction with the Brake/BRK output of the HM I/O set.

3.1.6 Mini USB communication (CN3)

Mini USB and a PC can be used as links for monitoring, drive test runs, or writing parameters. Refer to Chapter 4 for the operation.

3.1.6.1 Mini USB communication wiring diagram

Refer to HIWIN with a USB 2.0 Type A to mini-B 5-pin (1.8M) cable.

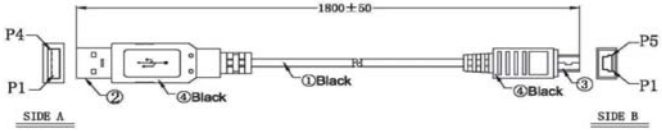


Fig. 3-14

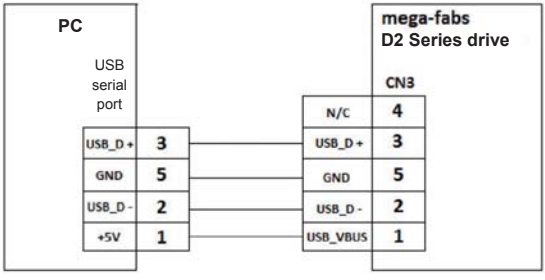
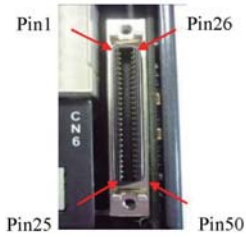
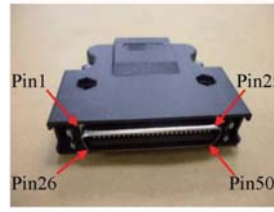


Fig. 3-15

3.1.7 CN6 connector



SCSI 50PIN (Female)



SCSI 50PIN (Male)

Fig. 3-16

3.1.7.1 CN6 pin definition

Table 3-2

Pin	Signal	Function
1	CWL	Low-speed (500 Kpps) pulse command Channel 1: Pulse, CW, A phase
3	CWL+	
4	CWL-	
2	CCWL	Low-speed (500Kpps) pulse command Channel 2: Dir, CCW, B phase
5	CCWL+	
6	CCWL-	
13	SG	Digital signal ground reference
21	A	Output pulse of feedback (buffered encoder or emulated encoder) RS422
22	/A	
48	B	
49	/B	
23	Z	
24	/Z	
25	SG	Digital signal ground reference
19	CZ	Z phase output (open collector)
14	ADC0+	Analog command input(Velocity/Torque)
15	ADC0-	
16	ADC1+	N/A
17	ADC1-	
18	ADC2+	
20	ADC2-	
43	DAC1	N/A
42	DAC2	N/A
44	CWH+	High-speed (4 Mpps) pulse command
45	CWH-	Channel 1: Pulse, CW, A phase
46	CCWH+	High-speed (4 Mpps) pulse command
47	CCWH-	Channel 2: DIR, CCW, B phase
7	COM	Common port for general purpose input signal; can be either Sink or Source
33	I1	General purpose input signal (‘Hardware Enable’ by default)
30	I2	General purpose input signal (programmable function)
29	I3	
27	I4	
28	I5	
26	I6	
32	I7	
31	I8	
9	I9	
8	N/A	N/A
35	O1+	General purpose input signal (programmable function)
34	O1-	
37	O2+	
36	O2-	
39	O3+	
38	O3-	
11	O4+	
10	O4-	
40	N/A	N/A
12	N/A	N/A
41	AGND	Analog signal ground reference
50	FG	Frame ground reference

3.1.8 CN7 connector

SCR connector 10PIN (male)

SCR connector 10PIN (female)

Fig. 3-17

Table 3-3

Pin	Signal	Function
1	+5V DC	Encoder power output(+5Vdc)
2	SG	Signal ground and +5Vdc ground
3	PS+	Serial encoder input
4	PS-	
5	A	Digital incremental encoder input
6	/A	
7	B	
8	/B	
9	Z	
10	/Z	

3.2 D2 drive accessories

3.2.1 Motor power cable

Part name	Description	Model no.	
Motor power cable	Without brake signal	HVPS04AA□□MA	Not flex resistant
		HVPS04AA□□MB	Flex resistant
	With brake signal	HVPS06AA□□MA	Not flex resistant
		HVPS06AA□□MB	Flex resistant

□□ Represents cable length as the following:

□□	03	05	07	10
Wire length (m)	3	5	7	10

3.2.2 Feedback signal cable

Part name		Model no.	Description
Feedback signal cable	13bit	HVE131AB□□MA	Not flex resistant
		HVE131AB□□MB	Flex resistant
	17bit	HVE171AB□□MA	Not flex resistant
		HVE171AB□□MB	Flex resistant

□□Represents cable length as the following:

□□	03	05	07	10
Wire length (m)	3	5	7	10

3.2.3 Control signal cable

part name	Model no.	Description
Control signal cable	LMACK02D	2m in length and connected to the host controller. The wire at the controller end of the signal cable is free and can be soldered depending on the host controller connector.

3.2.4 USB communication cable

Part name	Model no.	Description
USB communication cable	USB 2.0 Type A to mini-B 5-pin	1.8m in length with a mini-B connector at the drive end.

3.2.5 Accessory kit module

D2 drive model no.	Model no.	Description	Quantity
D2-xxxx-x-B(G).	D2-CK1	CN1: AC power, motor power, Regenerative resistor, and control power connector: 12 pins, pitch 5mm. Wago 721-112/026-000	1
		CN2: Brake connector: 3 pins, pitch 2.5mm. Wago 734-104	1
		CN6: Control signal connector: 50 pins solder type. 3M 10150-3000PE + 10350-52A0-008	1
		CN1 connector fixture: Wago 231-131	1
		CN2 connector fixture: Wago 733-103	1
D2-xxxx-x-B(F).	D2-CK2	CN1: AC power, motor power, Regenerative resistor, and control power connector: 12 pins, pitch 5mm. Wago 2092-1112	1
		CN2: Brake connector: 3 pins, pitch 2.5mm	1
		CN6: Control signal connector: 50 pins solder type. 3M 10150-3000PE + 10350-52A0-008	1
		CN2 connector fixture: Wago 733-103	1
D2-xxxx-x-B0.	D2-CK3	CN1: AC power, motor power, Regenerative resistor, and control power connector: 12 pins, pitch 5mm. Wago 721-112/026-000	1
		CN2: Brake connector: 4 pins, pitch 3.5mm	1
		CN6: Control signal connector: 50 pins solder type. 3M 10150-3000PE + 10350-52A0-008	1
		CN2 connector fixture: Wago 734-230	1

3.2.6 EMC accessory kit

Item name	Model no.	Description	Quantity
D2 EMC accessory pack for single-phase	D2-EMC1	Single-phase filter FN2090-6-06	1
		EMI core KCF-130-B	2
D2 EMC accessory pack for three-phase	D2-EMC2	Three-phase filter FN3025HL-20-71	1
		EMI core KCF-130-B	2

3.2.7 Regenerative resistor

Item name	Model no.	Resistance value	Rated power/instantaneous power
Regenerative resistor	RG1	68 Ω	100W/500W
Regenerative resistor	RG2	120 Ω	300W/1500W

3.2.8 Connector specifications

Connector	Specifications	HIWIN parts no.	Wire diameter	Remarks
AC main power cable connector (CN1) Motor power cable connector (CN1) Regenerative resistor connector (CN1) Control power cable connector (CN1)	EU 12-pin 5.0mm pluggable female connector	051500400269 WAGO: 2092-1112	12-24AWG Recommended: 12AWG/600V	Note 1
Control signal connector (CN6) Feedback signal connector (CN7)	50-pin .050" Mini D Ribbon (MDR), standard solder connector HIWIN standard encoder cable	051500400272SCSI 50 pin (male)	24-30AWG	Note 1
Brake connector (CN2)	EU 3-pin 2.5mm pluggable female connector	051500400251 WAGO: 733-103	20-28AWG	Fixture/tool: 733-130 Note 1
Mini USB communication connector (CN3)	USB 2.0 Type A to mini-B 5-pin (1.8m) (Shielded)	051700800366		Optional

Note 1: Accessories include CN1, CN2, CN6 (with 733-130 fixture/tool) connectors, HIWIN P/N: 051800200070.

Note: When wiring the product, turn off all power sources and use the fixture to avoid electric shock.

3.3 Standard main power circuit wiring

Attention

- Wiring and inspection must be conducted by professional technicians.
- Turn off the power before wiring or inspection to avoid electric shock or other dangers.
- High voltage may remain in the drive after the power is turned off. Wait a while (up to five minutes) before touching the power terminal.
- Perform the wiring appropriately and reliably to ensure stable operation and to avoid injury, damage or other accidents.
- Do not attempt to modify the drive.

3.3.1 AC power wiring diagram (single-phase)

It is recommended to use the FN2090-6-06 single-phase filter.

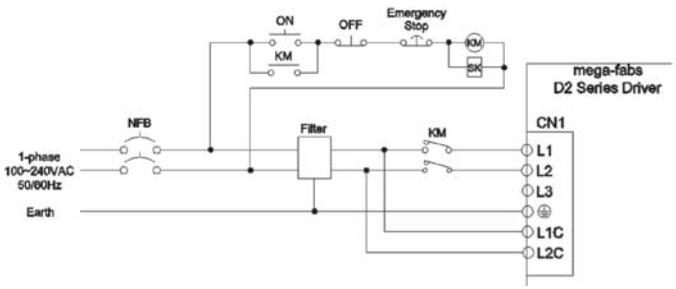


Fig. 3-18

FN2090-10-06 filter	
Maximum continuous operating voltage	250V AC, 50/60Hz
Operating frequency	DC to 400Hz
Rated current	10A@40°C, 11.2A@25°C
Surge pulse protection	2kV, IEC 61000-4-5

3.3.2 AC power wiring diagram (three-phase)

It is recommended to use the FN3258-7-45 three-phase filter.

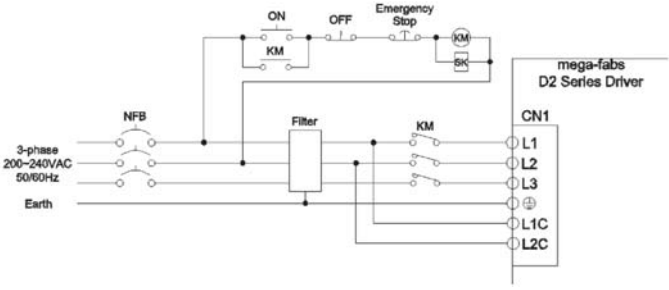


Fig. 3-19

FN3258-7-45 filter	
Maximum continuous operating voltage	3 x 480/277V AC (FN3258)
Operating frequency	DC to 60Hz
Rated current	7A@50°C, 7.7A@40°C
Drive power rating	4 KW
Current leakage@400V AC/50Hz	33.0 mA
Surge pulse protection	2kV, IEC61000-4-5

3.4 Multiple drive connection (example)

Note: Do not use the drive power connector for parallel connection with other drives.

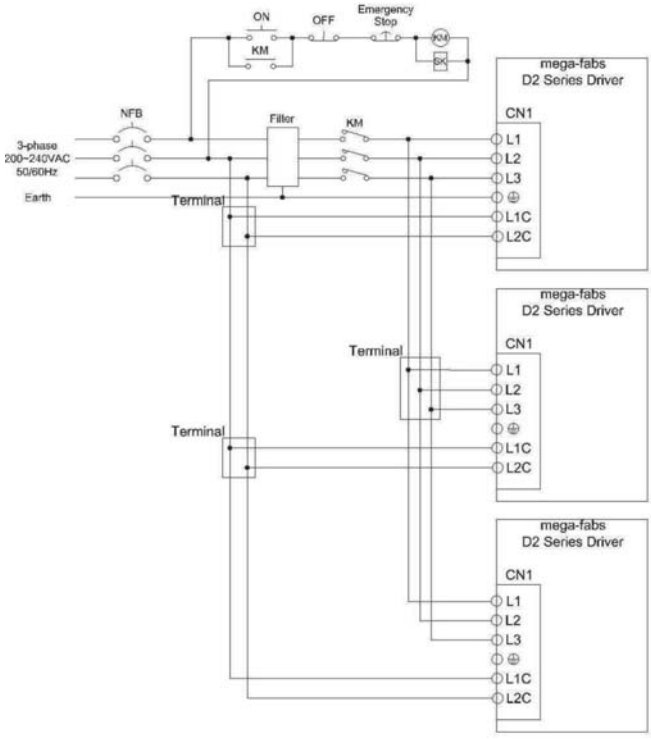


Fig. 3-20

3.4.1 Selection of no-fuse breakers (NFBs)

Fig. 3-4 Rated current of the D2 Series drives

Drive model no.	Rated input current A (rms)
D2-0123-◇-A□	1.5
D2-0423-◇-B□	4.1
D2-1023-◇-C□	7.5

When NFB is used for motor shunts, the rated capacitance is usually 1.5-2.5 times the rated current of the motor. The selection is described below:

One motor: $I_B=CxI_n$

Two or more motors that are started one at a time: $I_B=(\Sigma I_n-I_{nMAX})\times K+C_{MAX}\,I_{nMAX}$

Two or more motors that are started simultaneously:
$I_B=C1I_{n1}+C2I_{n2}+\cdots\cdots+CNI_{nN}$

[Note]

I_B: NFB rated current value.

I_n: Motor rated current value.

In_{MAX}: The maximum rated current value among different motors specifications.

C: Multiple of the rated current, usually 1.5-2.5, or 1.5 if the final multiple cannot be determined.

C_{max}: The multiple of the rated current based on the maximum rated current among the motors.

K: Demand rate; 1 is recommended if the final value cannot be determined.

Calculation example:

If five D2-0123-◇-A□ and one D2-0423-◇-B□ drives are used (assuming that C and C_{MAX} are doubled)

Started one at a time: I_B = (1.5*5+4.1-4.1) *1+4.1*2 = 15.7A

Started simultaneously: I_B =2*1.5+2*1.5+2*1.5+2*1.5+2*1.5+2*4.1 = 23.2A

3.5 I/O signal connection

The D2 drive provides 9 general purpose inputs and 4 general purpose outputs on its CN6 connector for use. Users can define the function of each I/O point using the software.

3.5.1 CN6 I/O signal function description

For more information on the function of CN6 I/O signal pins, please refer to Section 4.4.

Table 3-5

Pin	Signal	Function
1	CWL	Low-speed (500 Kpps) pulse command Channel 1: Pulse, CW, A phase
3	CWL+	
4	CWL-	
2	CCWL	Low-speed (500 Kpps) pulse command Channel 2: Dir, CCW, B phase
5	CCWL+	
6	CCWL-	
13	SG	Digital signal ground reference
21	A	Output pulse of feedback (buffered encoder or emulated encoder) RS422
22	/A	
48	B	
49	/B	
23	Z	
24	/Z	
25	SG	Digital signal ground reference
19	CZ	Z phase output (open collector)
14	ADC0+	Analog command input(Velocity/Torque)
15	ADC0-	
44	CWH+	High-speed (4 Mpps) pulse command Channel 1: Pulse, CW, A phase
45	CWH-	
46	CCWH+	High-speed (4 Mpps) pulse command Channel 2: DIR, CCW, B phase
47	CCWH-	
7	COM	Common port for general purpose input signal; can be either Sink or Source
33	I1	General purpose input signal (‘Hardware Enable’ by default)
30	I2	General purpose input signal (programmable function)
29	I3	
27	I4	
28	I5	
26	I6	
32	I7	
31	I8	
9	I9	
35	O1+	
34	O1-	
37	O2+	
36	O2-	General purpose input signal (programmable function)
39	O3+	
38	O3-	
11	O4+	
10	O4-	
41	AGND	Analog signal ground reference
50	FG	Frame ground reference

3.5.2 Digital input wiring

The D2 general purpose input pins use an optocoupler input interface that is suitable for 12-24V DC voltage systems. There are a total of 9 general purpose inputs with a COM port suitable for Sink and Source connections. I3 uses Axis Enable control by default and others are available for users to define HM functions based on their requirements.

3.5.2.1 Sink input wiring example

Input via a switch or relay:

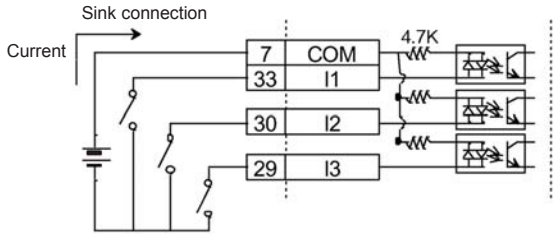


Fig. 3-21

Input via a transistor:

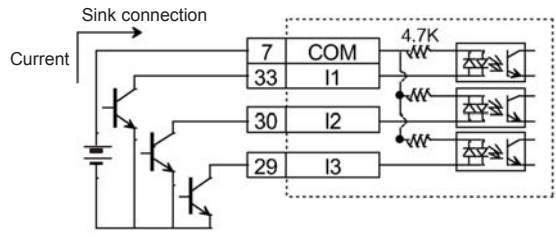


Fig. 3-22

3.5.2.2 Source input wiring example

Wiring for input via switches or relays:

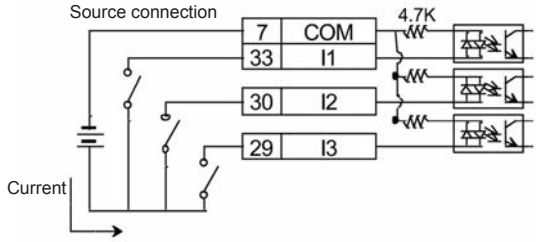


Fig. 3-23

Wiring for input via transistors:

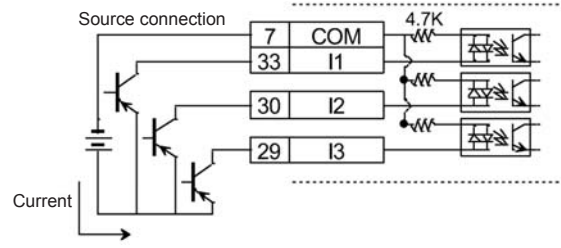


Fig. 3-24

3.5.3 Digital output wiring

The D2 general purpose output pins use an optocoupler Darlington output interface that is suitable for a voltage system of less than 24V DC. There are 4 general purpose outputs. Each output has an independent Darlington open collector circuit. The maximum allowable current is 100 mA. Users can define the function of each D2 output using the software.

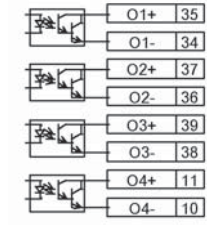


Fig. 3-25

3.5.3.1 Wiring for output via relays (example)

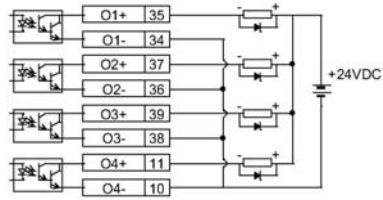


Fig. 3-26

3.5.3.2 Wiring for output via optical couplers (example)

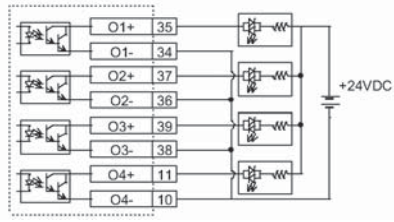


Fig. 3-27

3.6 Wiring examples by mode

3.6.1 Master wiring diagram for pulse command input

The host controller sends a pulse to the drive, which drives the motor to move a corresponding distance every time it receives a pulse. This pulse has a similar function to a position control command.

The position mode (P Command) receives host controller commands in three modes: PLS+DIR, CW/CCW and A/B Phase.

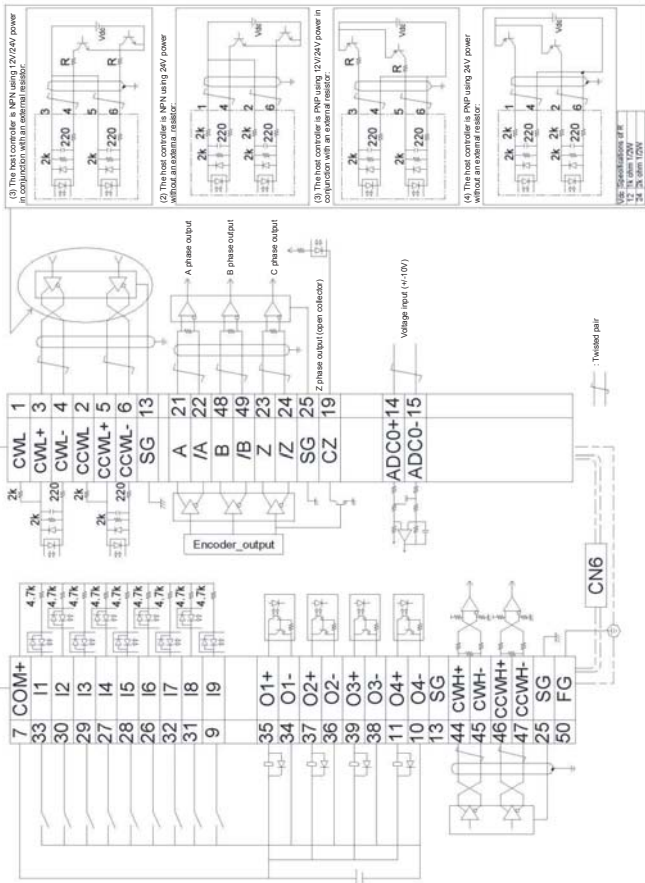


Fig. 3-28

3.6.1.1 High-speed pulse command

Wiring for the host controller with differential signal (example):

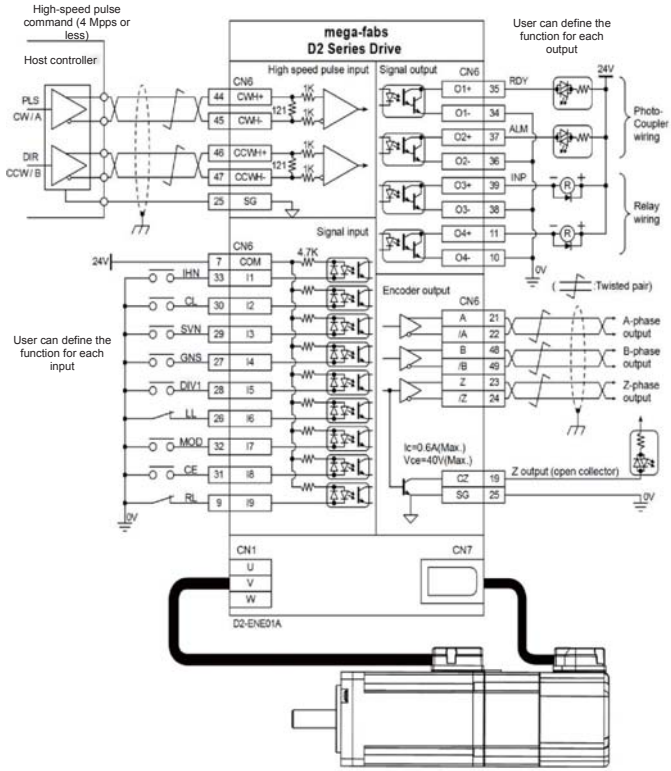


Fig. 3-29

3.6.1.2 Host controller is Sink (NPN) with current-limiting resistance

Wiring for the host controller with single-ended signal (example):

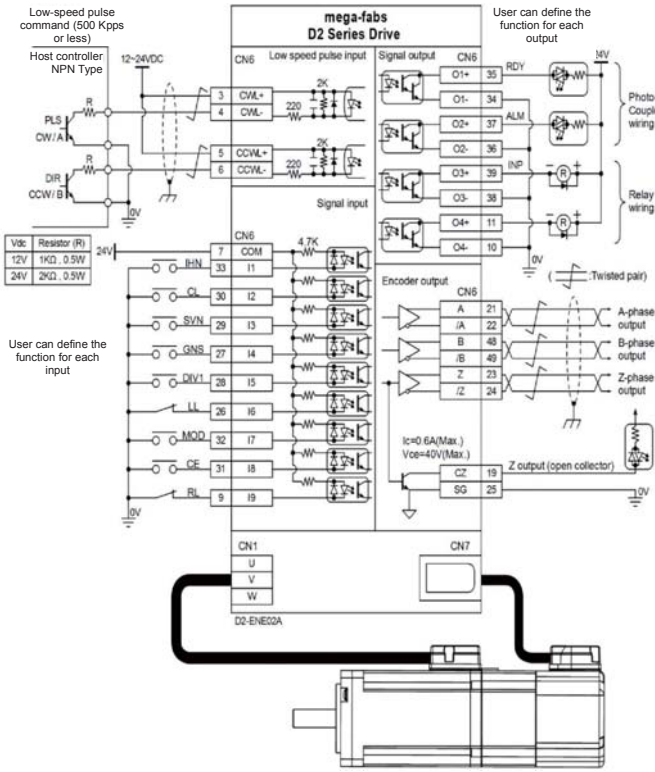


Fig. 3-30

3.6.1.3 Host controller is Sink (NPN) without current-limiting resistance

Wiring for the host controller with single-ended signal (example):

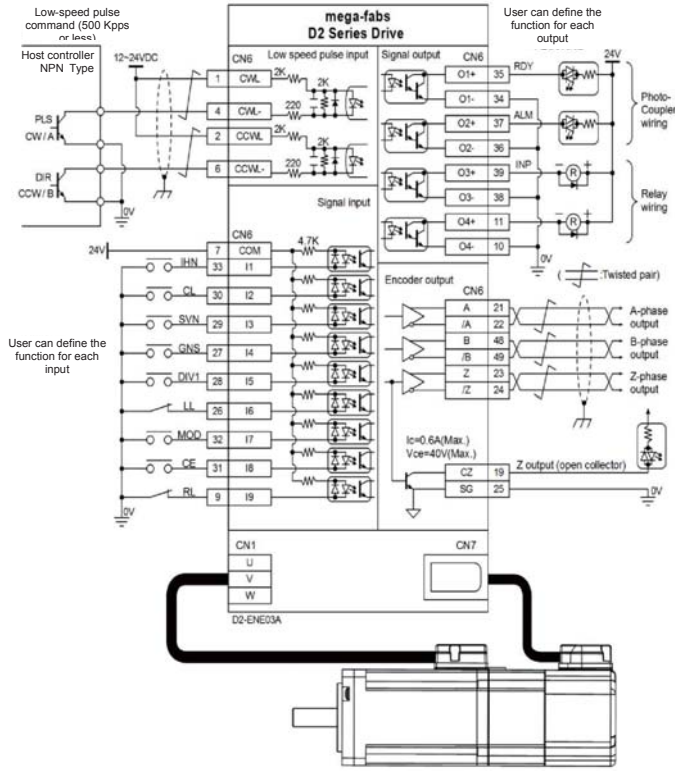


Fig. 3-31

3.6.1.4 Host controller is Source (PNP) with current-limiting resistance

Wiring for the host controller with single-ended signal (example):

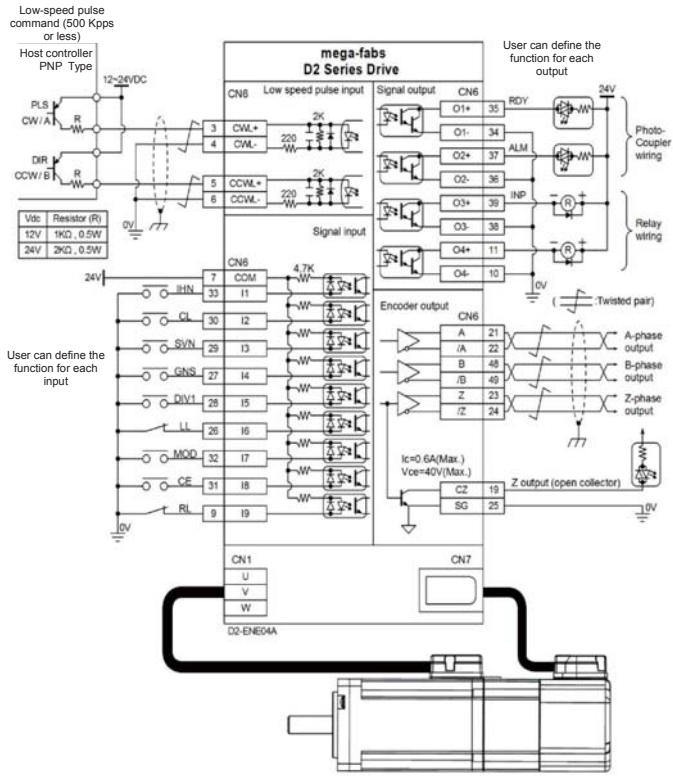


Fig. 3-32

3.6.1.5 Host controller is Source (PNP) without current-limiting resistance

Wiring for the host controller with single-ended signal (example):

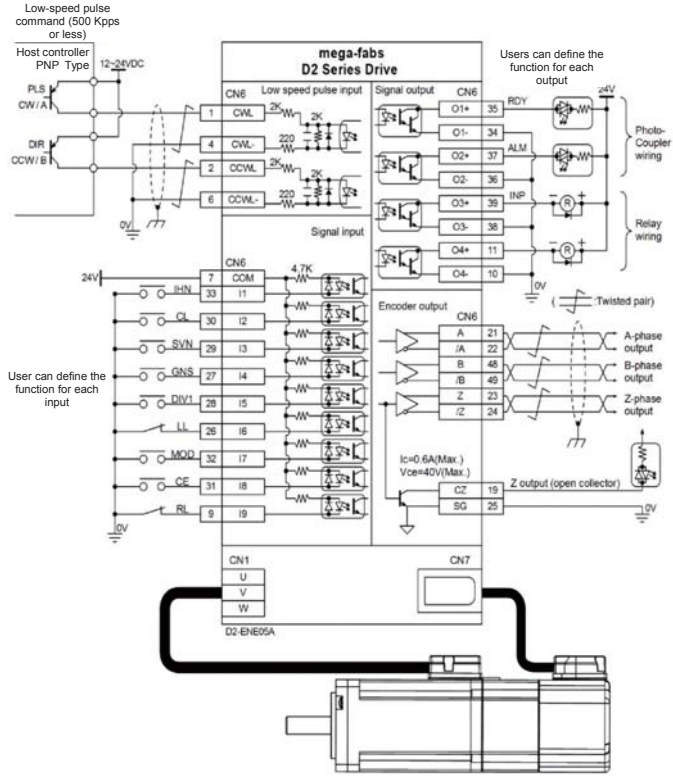
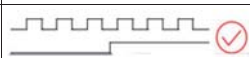
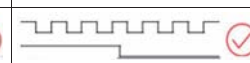
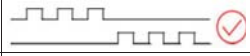
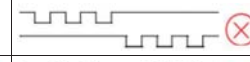
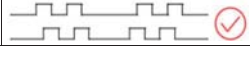
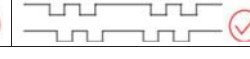


Fig. 3-33

※ Note

The signal logic of the pulse command received by the D2 drives (D2-0423-S-B(F) and D2-0423-S-B(G)) is shown below.

Table 3-6

Pulse command	Positive logic	Negative logic
Pulse Dir		
CW CCW		
A B		

If the host controller has a single-ended negative logic CW/CCW signal, it can be converted to a positive logic CW/CCW signal using the wiring below..

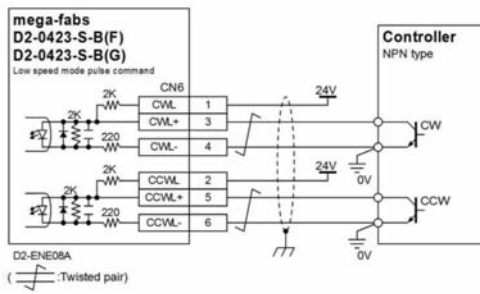


Fig. 3-34 Wiring for conversion from a single-ended negative to positive logic CW/CCW signal

3.6.2 Master wiring diagram for analog command input

The drive can receive voltage commands from the host controller (known as V command). The input voltage ranges from +10V to -10V. The drive can control velocity or current of the motor corresponding to the external voltage commands from +10V to -10V.

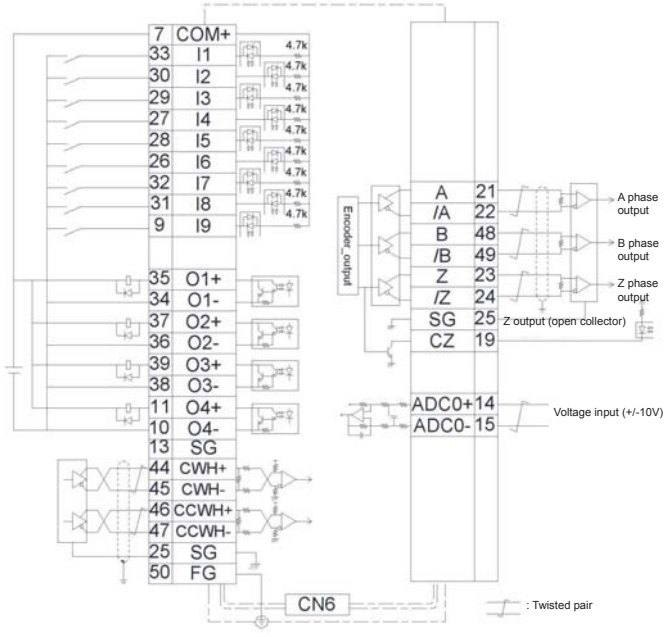


Fig. 3-35

3.6.2.1 Velocity mode

Wiring for the host controller with a voltage of +10V to -10V (example):

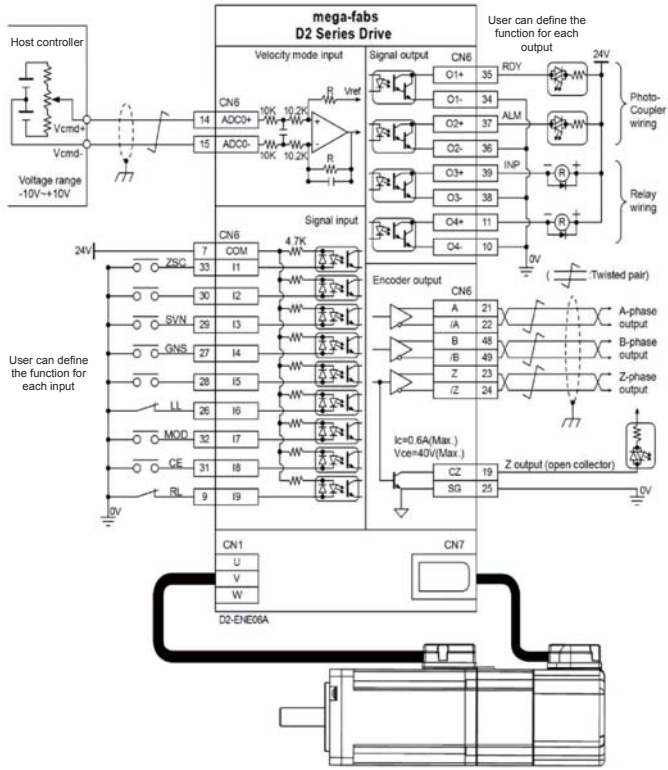


Fig. 3-36

3.6.2.2 Force/Torque mode

Wiring for the host controller with a voltage of +10V to -10V (example):

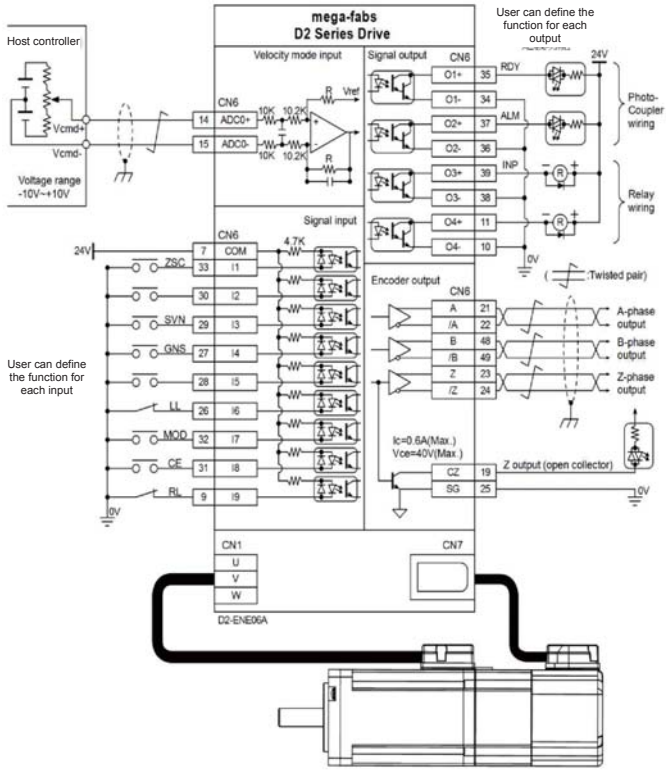


Fig. 3-37

3.6.3 Master wiring diagram for PWM command input

In addition to the analog command, D2 drives can receive PWM commands in the velocity and force/torque modes. The PWM command is classified into single-wire (PWM 50%) and two-wire (PWM 100%) types. For more information, please refer to the velocity and force/torque modes in 4.6.2 and 4.6.3.

3.6.3.1 Velocity/torque mode PWM 50% input (Host controller is NPN)

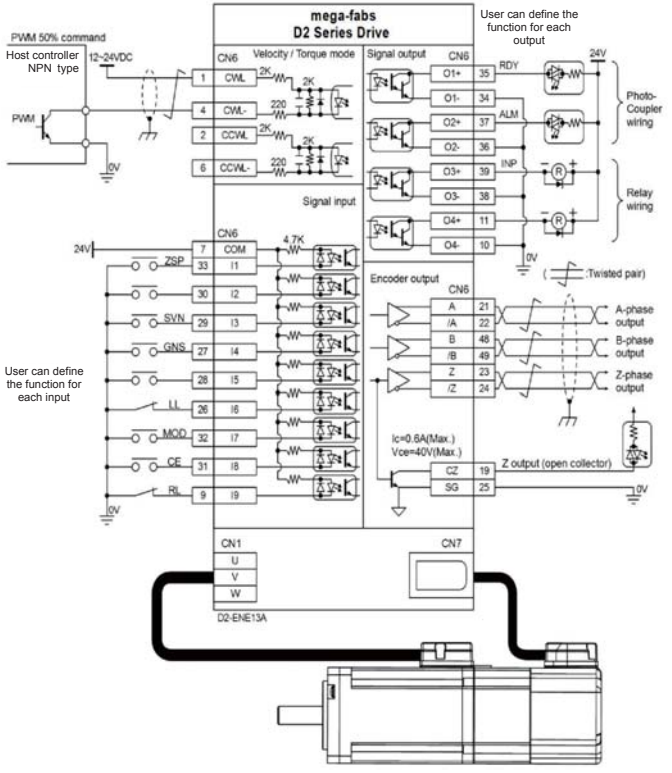


Fig. 3-38

3.6.3.2 Velocity/torque mode PWM 100% input (Host controller is NPN)

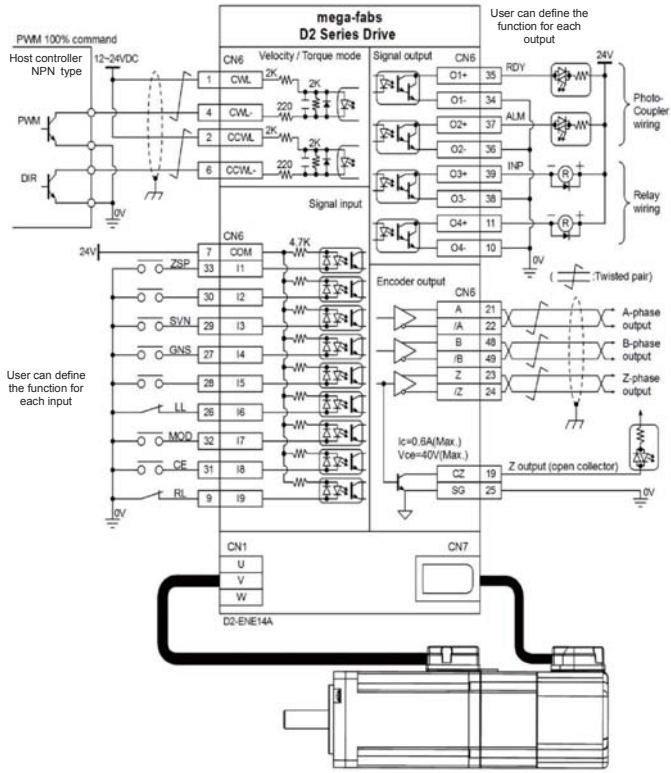


Fig. 3-39

3.6.3.3 Velocity/torque mode PWM 50% input (Host controller is 5V TTL)

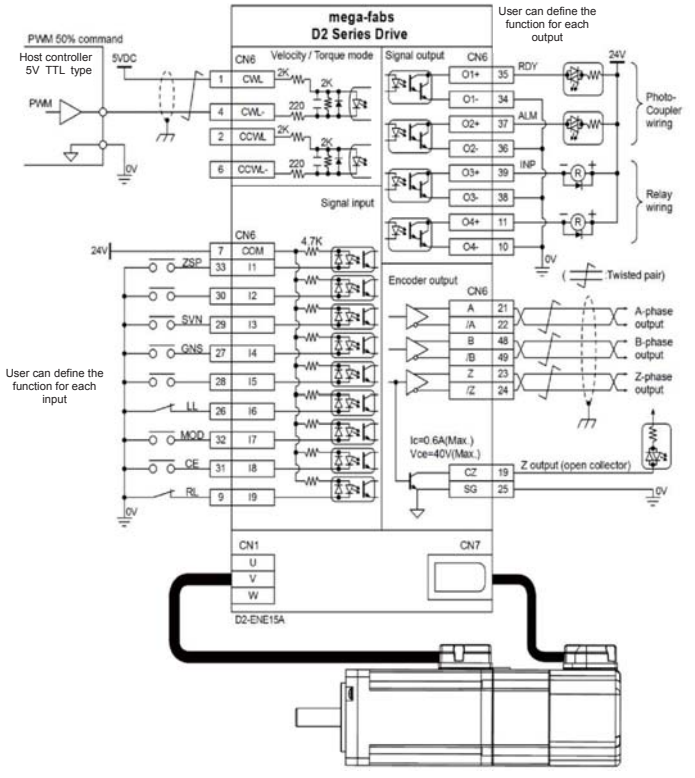


Fig. 3-40

3.6.3.4 Velocity/torque mode PWM 100% input (Host controller is 5V TTL)

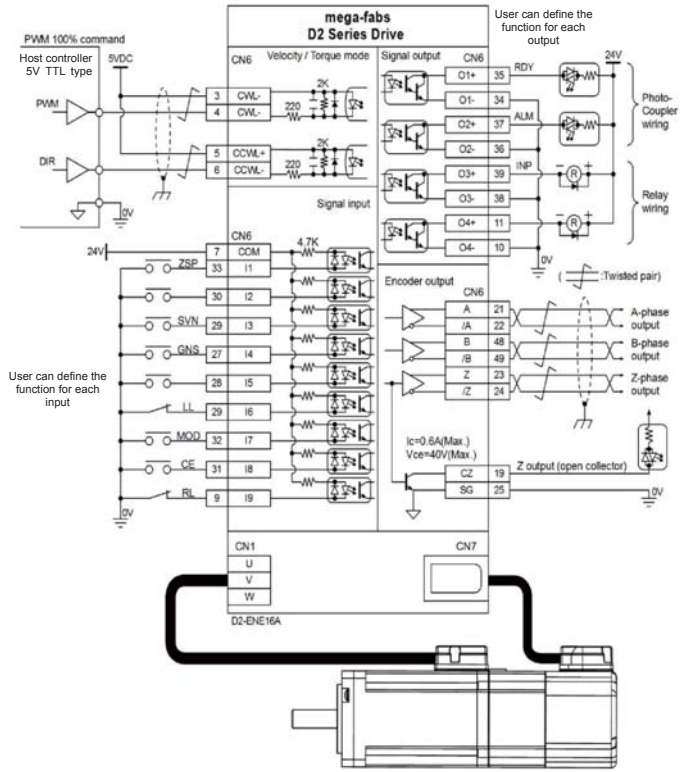


Fig. 3-41

4 Settings

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4.1 Installation and connection

The human-machine interface(HMI) that D2 drives use is called Lightening. The communication between drive and PC is a USB connection. The Lightening graphical HMI on your PC can perform the functions including motor initialization, motor configurations, motion control, motor test runs and the corresponding parameter saving. This section describes how to install the product and connect it to your PC.

4.1.1 Setup file

The setup folder of the Lightening graphical HMI contains, among others, an auto execution file ‘setup.exe’ and a firmware folder ‘dce’ as shown in Fig. 4-1.

Fig. 4-1 Setup file

Please log in and download the setup file from the Internet. The path to the file is:

http://www.hiwinmikro.com.tw/Support_Download_Cad.aspx?type=RM. Execute ‘setup.exe’ directly after completing downloads. The installation screen is shown in Fig. 4-2. The preset destination for the installation is “C:\mega_fabs\”. Do not try to change this path. Press ‘Start’ to perform the auto installation procedure. When the setup procedure is completed, a popup window appears to show successful installation of the software as shown in Fig. 4-3. If the USB drive installation screen (Fig. 4-4) appears during the setup procedure, click ‘Install’ and ‘OK’ to finish the setup procedure.

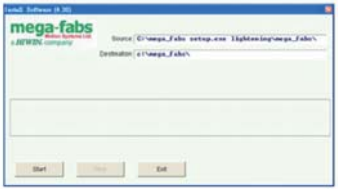


Fig. 4-2 Installation screen of the software

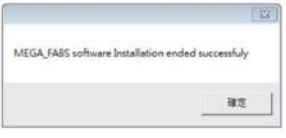


Fig. 4-3 Successful installation of the software

Fig. 4-4 Installation window for USB driver

The execution shortcut of the Lightening HMI program (Fig. 4-5) will appear on your PC desktop after installation. The path for this shortcut is:

“C:\mega_fabs\dce\toolswin\winkmi\lightening.exe”

Fig. 4-5 Execution shortcut of the Lightening HMI program

4.1.2 Communication setup

Connect the drive via USB and turn on the power before opening Lightening. The drive will automatically connect to the Lightening HMI when it is opened. If not, click 'Communication setup' in the 'Tools' menu to change the communication setup". The shortcut for this task is Ctrl+N.

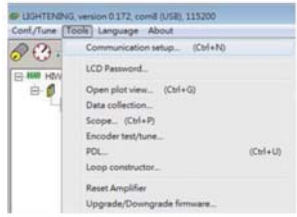


Fig. 4-6 Communication setup

The communication setup screen is shown below. The D2 drive supports USB connections. "BPS" field shows the transmission rate and the default value is 115,200 bps (this should not be changed). The communication port is set in "Port" field. The field will display the existing port on your PC. Select the port that drive is actually connected to. Use default values in the remaining fields and the Lightening can be successfully communicated with drive.

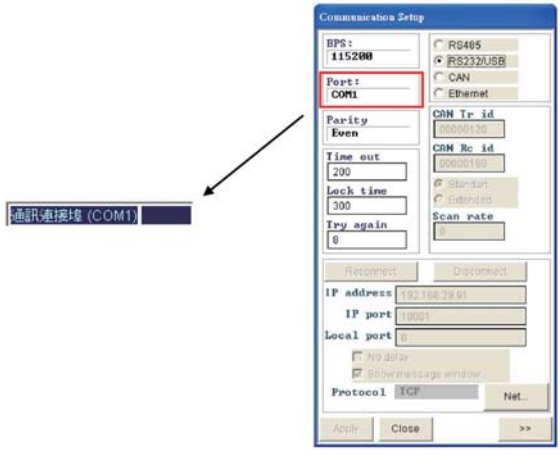


Fig. 4-7 Connection and transfer rate settings

4.1.3 Main HMI window

The main HMI after the connection is shown in the following. The function of each button in the main toolbar is described as below.

: Save parameters in the RAM to file.

: Load parameters in the file to RAM.

: Save parameters in the RAM to FLASH.

reset : Reset the drive.

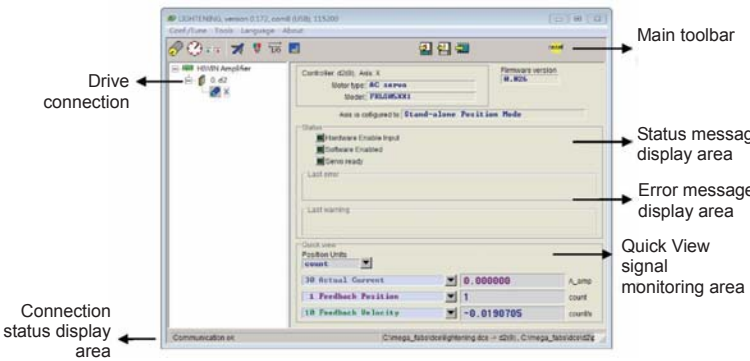


Fig. 4-8 Main HMI window

Status message display

There are three indicators for displaying the status message.

Servo ready : This light is green when the drive is enabled and goes out when the drive is disabled.

Hardware Enable Input : This light is green when hardware is enabled. The drive cannot enable the motor if hardware is not enabled. Please refer to Appendix B for more information to enable hardware by using external input.

Software Enabled : This light is green when software is enabled. Both hardware and software must be enabled for driving the motor. Click the 'Enable' button in the 'Performance Center' to enable the software, or click the 'Disable' button to disable the software. If there is no connection between your PC and the drive, the status of software enable is changed with the status of hardware enable. If you close Lightening when PC is connecting with drive, the Lightening HMI will query you whether want to enable or disable software after the window is closed.

When using Lightening 0.144 (or older versions) for connection to a D2 drive, an installation error message as shown in Fig. 4-9 appears after the connection. This is because these HMI versions do not contain and cannot identify the firmware version (e.g. v0.006) of the D2 drive. Please click 'Do nothing' and download the latest Lightening HMI software version from the HIWIN website.

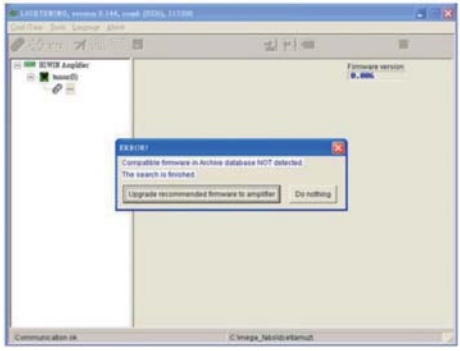

Compatible firmware in Archive database NOT detected.
The search is finished.
Upgrade recommended firmware to amplifier
Do nothing

Fig. 4-9 Firmware version installation error message

4.2 Configuration Center

When using a new drive or a new motor, please set up all required options according to your actual needs Through 'Configuration Center'. Click in the main function toolbar to enter the Configuration Center. The position of the button is shown in Fig. 4-10.

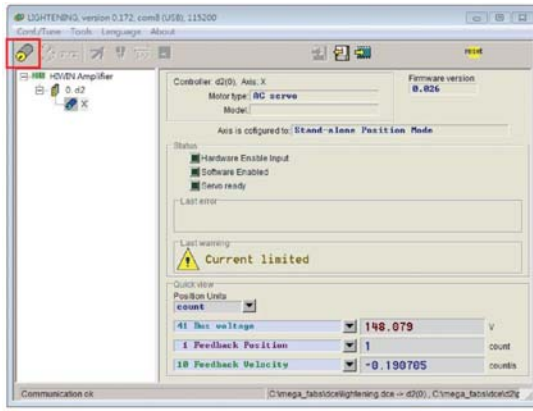


Fig. 4-10 Main functions screen

The following steps must be finished for using D2 drive to drive a motor:

1. Motor type: Set the type of motor and all related parameters.
2. Encoder parameters: Set the type of encoder and its resolution.
3. Operation mode: Set the operation mode at drive.

The settings procedure is described step-by-step in 4.2.1.

4.2.1 Motor configuration

D2 drive supports AC servo motors. The motor configuration page is at the first page of the Configuration Center. The options are under HIWIN Motors.

AC servo motor settings

1. Motor parameters

Click a HIWIN AC servo motor model to set and display the parameters for the selected motor.

2. Operation parameters

Screw Moment of Inertia: The rotational inertia of the screw used. Unit: Kg* (m^2).

Load Mass: The mass to be loaded. Unit: Kg.

Screw Pitch: The pitch of the ball screw (i.e. the linear movement amount of the screw in a revolution). Unit: mm

Gear Ratio: The ratio of the gear teeth number at the load end to the gear teeth number at the drive end.

Input the correct values of motor operation parameters can help drive to calculate the suitable values for driving parameters and thus successfully drive the motor.

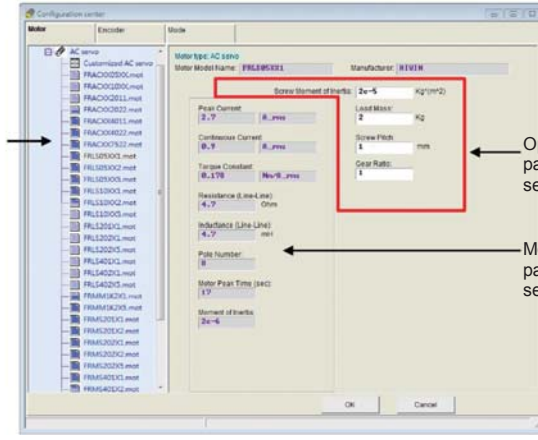


Fig. 4-11 Motor parameter settings

Customized motor settings

Hardware parameters for motors other than standard HIWIN products can also be entered in the customized motor settings area. For servo motor systems, open AC servo' and select 'Customized AC servo' as shown in the following figure. Enter, then enter the required parameters according to the specifications of the motor. Use the 'Save' function to save the motor parameters after the settings have been entered. This will create a motor parameter file (*.mot) that can be loaded at any time in the future.

1. Basic motor parameters

   Peak Current: The maximum current that a motor can sustain temporarily. Unit: A_amp or A_rms.

   Continuous Current: The maximum current that a motor can sustain continuously. Unit: A_amp or A_rms.

   Force/Torque Constant: The characteristics of the motor coil , Its unit is force or torque of the current. Unit: N/A_amp, N/A_rms, Nm /A_amp or Nm /A_rms.

   Resistance (Line-Line): The characteristics of the motor coil indicating the resistance value between coils. Unit: Ohm.

   Inductance (Line-Line): The characteristics of the motor coil indicating the inductance value between coils. Unit: mH.

   Pole Number: The total number of magnetic poles in one revolution (360°) of a rotary motor.

   Motor Peak Time: The time for which a motor is allowed to sustain the peak current. Unit: sec.

   Moment of Inertia: The rotational inertia of a motor in operation. Unit: Kg* (m^2).

2. Motor operation parameters

   Screw Moment of Inertia: The rotational inertia of the screw used. Unit: Kg* (m^2).

   Moving or Load Mass: The total mass of a moving object. Unit: Kg.

   Screw Pitch: The pitch of an acme or ball screw (i.e. the feed amount of the screw in a single revolution). Unit: mm.

   Gear Ratio: The ratio of the gear teeth number at the load end to the gear teeth number at the drive end.

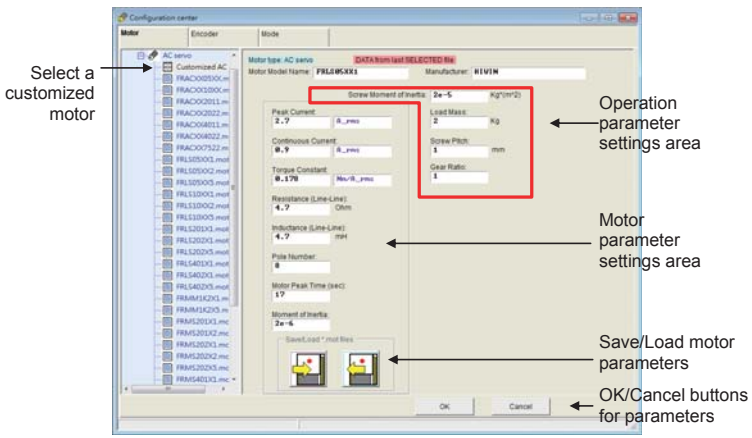


Fig. 4-12 Customized motor parameter settings

4.2.2 Encoder configuration

The drive normally receives a feedback signal from the position encoder to perform servo control. The encoder settings page is shown in Fig. 4-13. Please select or set the correct type and parameters of the encoder on this page.

Note: If user uses a HIWIN series torque motor or AC servo motor, then just select the correct motor model and the program will automatically create a link to the encoder parameters applicable to this motor. If a HIWIN series AC motor is being used, the program will automatically create a link to the digital rotary encoder the its resolution is 10,000 count/rev.

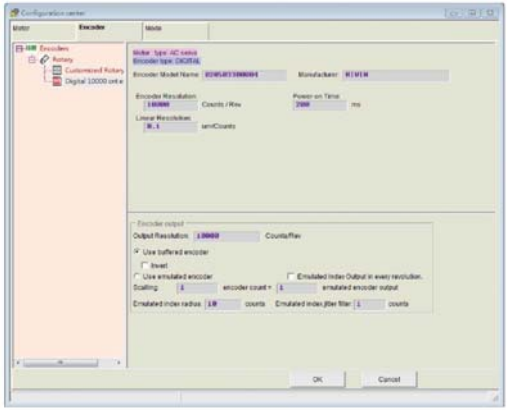


Fig. 4-13 Encoder settings interface

Besides, there are a variety of resolution parameters commonly used with HIWIN motor on encoder settings page, enter parameters for any third-party encoder in the customized settings field on the same page. For example, for a digital rotary encoder, open 'Rotary' and select 'Customized Rotary Digital' to enter the resolution parameter based on the specifications of the encoder. Use the 'Save' function to save the encoder parameters after the settings have been entered. This will create an encoder parameter file (*.enc) that can be loaded at any time in the future (Fig. 4-14).

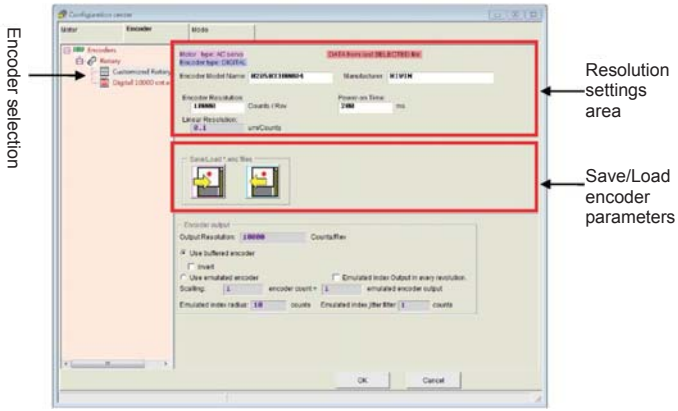


Fig. 4-14 Customized encoder settings interface

The D2 drive can be used with a digital rotary encoder:

To work with the host controller, the D2 drive can transmit an encoder signal in addition to receiving a signal from an encoder. The drive can provide buffered encoder output or emulated encoder output. When using the emulated encoder output, the resolution can be changed for the output via the scaling settings. Please refer to Section 4.2.2.3 for more information.

4.2.2.1 Digital incremental encoder

If a HIWIN series AC servo motor is used, simply clients just need to select the motor model name. The program will create a automatically link to the encoder parameters applicable to the motor; no other encoder settings are required. For HIWIN motors, which its ninth digit of the model is 1 or 5 means that the motor uses a 13-bit digital incremental rotary encoder with a resolution of 10,000 count/rev. The ninth digit of the model is 3 means that the motor uses a 17-bit digital incremental rotary encoder with a resolution of 131,072 count/rev.

If the resolution parameter needs to be set for a customized digital incremental rotary encoder, please refer to Section 4.2.2.2.

Table 4-1 shows the digital rotary encoders that can be used with HIWIN AC servo motors FRAC, FRLS, FRMS and FRMM series.

Table 4-1

AC servo motor model		Count/rev
FRAC series	FRACXX1011, FRACXX1022, FRACXX2011, FRACXX2022, FRACXX4011, FRACXX4022, FRACXX7522	13-bit Incremental (10,000 counts/rev)
FRLS series	FRLS05XX1, FRLS10XX1, FRLS201X1, FRLS202X1, FRLS401X1, FRLS402X1, FRLS05XX5, FRLS10XX5, FRLS202X5, FRLS402X5	
FRMS series	FRMS201X1, FRMS202X1, FRMS401X1, FRMS402X1, FRMS752X1, FRMS202X5, FRMS402X5, FRMS752X5	
FRMM series	FRMM1K2X1, FRMM1K2X5	
FRLS series	FRLS05XX3, FRLS10XX3, FRLS201X3, FRLS202X3, FRLS401X3, FRLS402X3	17-bit Incremental (131,072 counts/rev)
FRMS series	FRMS201X3, FRMS202X3, FRMS401X3, FRMS402X3, FRMS752X3	
FRMM series	FRMM1K2X3	

4.2.2.2 Customized digital incremental encoder

If the resolution for a customized encoder (e.g. digital rotary encoder) needs to be set, open ‘Rotary’ and select ‘Customized Rotary Digital’. Enter the resolution parameters according to the specifications of the encoder. In the ‘Encoder Resolution’ field, shown in Fig. 4-15, enter the total number of encoder position signals after one revolution of the motor. The unit is counts/rev. The software will automatically calculate the “Linear Resolution” according to the screw pitch and the resolution of the encoder. The unit is um/counts.

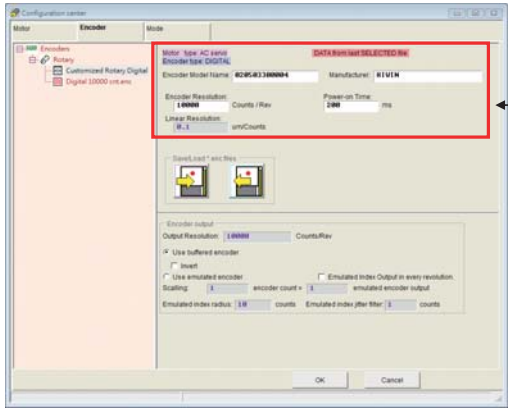


Fig. 4-15 Customized resolution parameter settings

4.2.2.3 Encoder output settings

The D2 drive transmits an A&B square wave encoder signal via CN2. This can be connected to the host controller if needed. Check the 'Used buffered encoder' or 'Use emulated encoder' in the encoder output area accordingly (Fig. 4-16). The value in the 'Output Resolution' field will be updated for the selected output mode.

※ Using AC servo motors with a 17-bit encoder can use the emulated encoder (Fig. 4-18, Emulated Index Output in every revolution) to output the Z phase signal to the host controller.

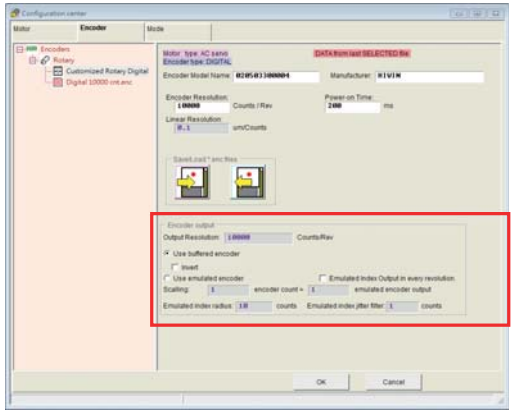


Fig. 4-16 Encoder output settings

Buffered encoder output

When this setting is selected, the drive will forward the signal sent by the encoder to the host controller. The 'Invert' function can also be checked, if needed, it allows the drive to inverse and then send it. The resolution of the signal being outputted is displayed on the screen for reference.

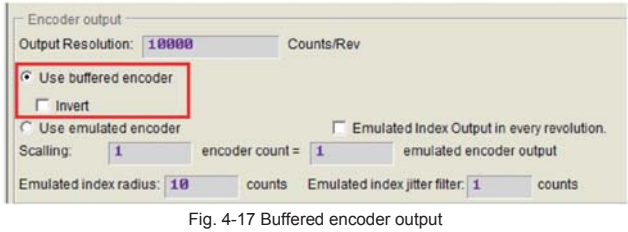

Encoder output
Output Resolution: 10000 Counts/Rev
Use buffered encoder
Invert
Use emulated encoder
Emulated Index Output in every revolution.
Scalling: 1 encoder count = 1 emulated encoder output
Emulated index radius: 10 counts Emulated index jitter filter: 1 counts

Fig. 4-17 Buffered encoder output

Emulated encoder output
When this setting is selected, the drive will multiply the position signal received from the encoder by a ratio (scaling) and send the result to the host controller. If the ratio is 1:1, the drive will directly output the encoder signal using the current encoder and resolution that has been set. Sometimes the host controller cannot receive an encoder signal set at higher frequency. In this case, a different ratio (e.g. 5 encoder count = 1 emulated encoder output) can be used.

If an analog signal from an analog encoder is divided into very small segments, scaling might be needed to reduce the output resolution of the encoder. The output direction can be changed when the ratio is set to 1 encoder count = -1 emulated encoder output. In Fig. 4-18, for example, the encoder resolution is 10,000 count/rev and the scaling for the emulated encoder output is 5 encoder count = 1 emulated encoder output, so the 'Output Resolution' becomes 2,000 count/rev.

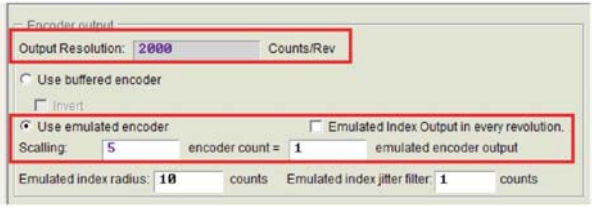

Encoder output
Output Resolution: 2000 Counts/Rev
Use buffered encoder
Invert
Use emulated encoder
Emulated Index Output in every revolution.
Scalling: 5 encoder count = 1 emulated encoder output
Emulated index radius: 10 counts
Emulated index jitter filter: 1 counts

Fig. 4-18 Emulated encoder output

Transmission of Z phase signal to the host controller
When an AC servo motor with a 17-bit encoder is used, and the encoder output mode is set to emulated encoder output, the Z phase signal can be sent to the host controller. The option for this setting is the 'Emulated Index Output in every revolution' in Fig. 4-18.

Transmission of Z phase signal:

1. If the 'Emulated Index Output in every revolution' option is not checked, the drive sends the Z phase signal only when it reaches the index position for the first time.

2. If the 'Emulated Index Output in every revolution' option is checked, the drive sends the Z phase signal every time when it reaches the index position.

4.2.3 Setting the operation mode

The settings screen for the operation mode is shown in Fig. 4-19. After the above parameters of three steps setting has setting has been completed, the operation mode parameters must be set for the drive.

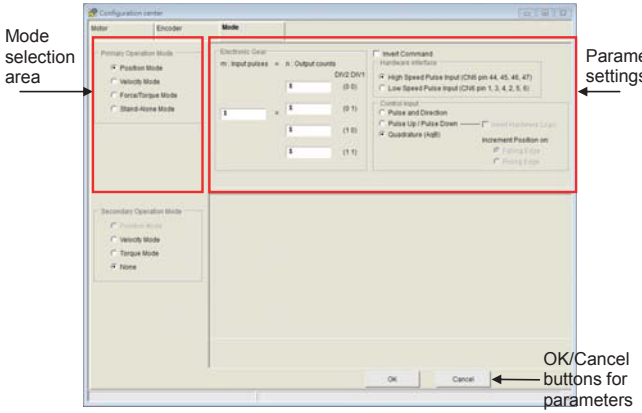
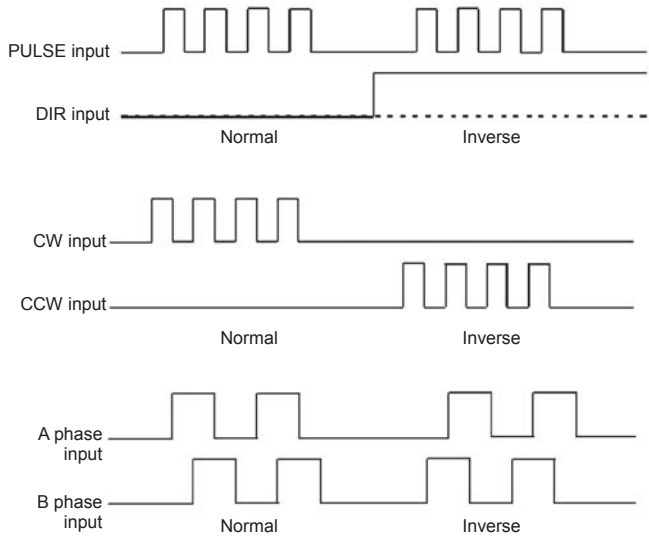


Fig. 4-19 Operation mode settings

4.2.3.1 Position mode principles

The host controller sends a pulse to the drive, and this pulse has a similar function to a position control command, thus the drive moves a corresponding distance every time it receives a pulse. The host controller is responsible for route planning. The pulse is sent more quickly when the motor is accelerated, and is sent at a fixed frequency when the motor moves at a constant speed. As shown in following figure the pulse is generated in three formats: PulseE/Dir, Pulse Up/Pulse Down or CW/CCW, and AqB phase (Quadrature) square wave.

The electronic gear can be set in the pulse mode. One input pulse normally corresponds to one encoder count. A gear ratio of 2:3, for example, means 2 input pulses correspond to 3 encoder counts. The pulse signal is classified into TTL differential and single-ended signals according to the wiring method of the hardware.



4.2.3.2 Setting the position mode

If the host controller only sends pulse command, the position mode must be selected to receive the external motion pulse command. The close-loop control is dealt with by the drive. The D2 drive supports three pulse formats and is also allowed to set the electronic gear ratio for the high-speed application system.

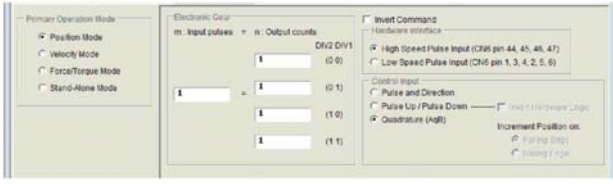


Fig. 4-20 Position mode settings

4.2.3.3 Velocity mode principles

V Command

The drive can receive command from the host controller via voltage (known as V commands). The input voltage ranges from +10V to -10V. The drive makes the received +10V to -10V input voltage correspond to different velocities.

The analog voltage signal is converted to a velocity command and the drive controlling the operating velocity of the motor. The higher the voltage value, the higher the output speed (but it will not exceed the upper limit set by the drive). Conversely, the lower the voltage value, the lower the output speed. When the voltage value is negative, the output speed becomes negative also and the motor operates inversely. The command speed to which the unit voltage corresponds can be set in the drive.

PWM Command

In addition to the voltage, the host controller can send commands via PWM signals (known as PWM commands).The PWM command converts to different velocity or current commands depending on the duty cycle. It is classified into single-wire (PWM-50%) and two-wire (PWM-100%) types. The single-wire (PWM-50%) type refers to the duty cycle of 50%. An inverse motion occurs when the duty cycle is less than 50%, while normal motion occurs when the duty cycle is more than 50%. The two-wire (PWM-100%) type needs one more pin to control the operation direction of the motor. The PWM command is converted to a velocity command to directly control the operation speed of the motor. The velocity to which the Full PWM corresponds can be set in the drive.

4.2.3.4 Setting velocity mode

Velocity mode can be selected if the host controller is used to send analog commands or PWM commands. Only the ratio (scaling) between the external command and velocity has to be set for the velocity mode. The unit shows the corresponding relationship of 1 V with mm/s or rpm or between the Full PWM and the highest speed.

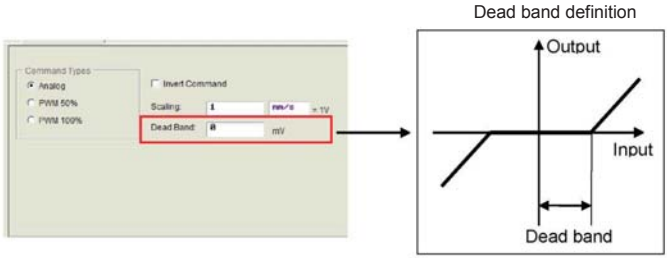


Fig. 4-21 Setting velocity mode

4.2.3.5 Force/torque mode principles

V Command

The drive can receive commands from the host controller via voltage (known as V commands). The input voltage ranges from +10V to -10V. The drive makes the received +10V to -10V input voltage correspond to the current control to drive the motor. The analog voltage signal is converted to a current command to directly control the current output of the drive and thus the force and torque of the motor. The higher the voltage value, the higher the output current (but it will not exceed the upper limit set by the drive). Conversely, the lower the voltage value, the lower the output speed. When the voltage value is negative, the output speed becomes negative too and the motor operates inversely. The current to which the unit voltage corresponds can be set in the drive.

PWM Command

In addition to the voltage, the host controller can send commands via PWM signals (known as PWM commands).The PWM command converts to different velocity or current commands depending on the duty cycle. It is classified into single-wire (PWM-50%) and two-wire (PWM-100%) types. The single-wire (PWM-50%) type refers to the duty cycle of 50%. An inverse motion occurs when the duty cycle is less than 50%, while normal motion occurs when the duty cycle is more than 50%. The two-wire (PWM-100%) type needs one more pin to control the operation direction of the motor. The PWM command is converted to a current command to directly control the current output and thus the force and torque of the motor. The current to which the Full PWM corresponds can be set in the drive.

4.2.3.6 Setting force/torque mode

Force mode is another application of the host controller that can send analog commands or PWM commands. Only the ratio (scaling) between the external command and the current has to be set for the force/torque mode. The unit shows the corresponding relationship of 1 V with the ampere or between the Full PWM and the highest ampere value of the current.

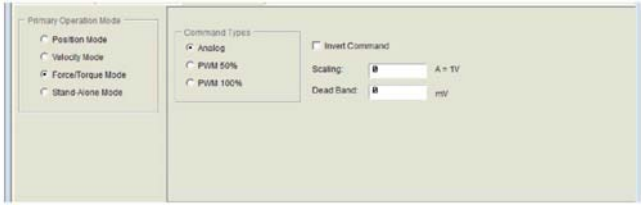


Fig. 4-22 Setting force/torque mode

4.2.3.7 Stand-Alone mode

Stand-Alone mode can be selected for drives that will be tested alone or used without any host controller (e.g. only the servo end and drive end are used). This model allows the drive to handle all loop controls.

Fig. 4-23 Stand-Alone mode

4.2.4 Completion of the configuration procedure

After completing the four parameter setting steps above for the motor, encoder, hall sensor and operation mode at the bottom of the screen, a window as shown in Fig. 4-24 appears showing the parameters before and after the settings for comparison. After confirming the settings, click 'Send to RAM' to send the parameters to the drive. The screen returns to the Configuration Center if 'Cancel' is clicked.

To retain this set of parameters, click ('Save to Flash') in the main HMI window to save the parameters in the flash memory. Parameters saved in the flash memory will be retained even if the drive is turned off.

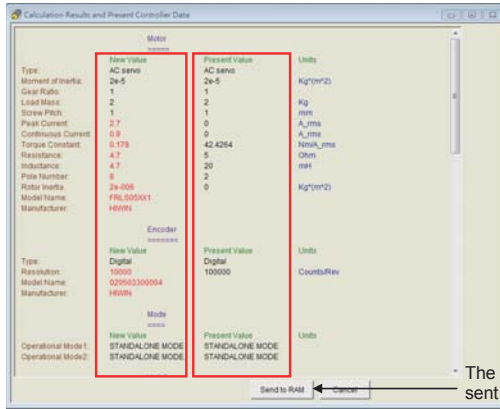


Fig. 4-24 Completion of the configuration procedure

To be save the parameters to a file on your PC, click ('Save Parameters from Amplifier RAM to File') to save the parameters to a file. The file extension is *.prm.

4.3 Auto phase center

4.3.1 Mode overview

4.3.1.1 SM mode

The SM mode has an open-loop control structure and the motor operates like a stepping motor. In this mode, it can be confirmed if the force direction of the motor is consistent with the feedback reading direction of the position encoder, or if the encoder settings are correct. If the force direction of the motor and the position encoder are set incorrectly, or if the output direction is not consistent with the feedback reading direction of the position encoder, then subsequent phase initialization may fail.

4.3.1.2 Phase initialization

Drive that use an incremental position encoder must undergo the motor angle searching process (known as 'phase initialization') when powered on for the first time. HIWIN linear servo motors can find the motor angle successfully when the drive is started and excited for the first time; almost no movement is needed for the motor to find the angle. Hall sensors are also a commonly used means of phase initialization.

4.3.1.3 Methods overview

Click in the main function tool bar to open the auto phase center. The drive provides the following four phase initialization methods:

SW method 4
This mode features a hall sensor built in with the wire-saving incremental encoder. No additional wiring is needed for a successful phase initialization and the motor will not shudder during the initialization process.

This method is used in conjunction with drives that have 0 in the ninth digit of the model number, and with motors that have 5 in the ninth digit of the model number, such as the drive D2-0423-S-B-0 and motor FRLS4020506A.

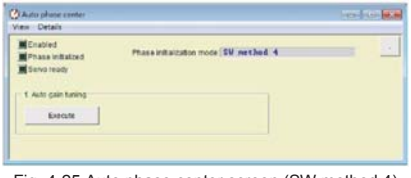


Fig. 4-25 Auto phase center screen (SW method 4)

SW method 1

This mode is for 13-bit digital incremental encoders. Only a slight movement of the motor is needed for a successful phase initialization. No hall sensor is required in this method.

This method is used in conjunction with drives that have 0 in the ninth digit of the model number, and with motors that have 1 in the ninth digit of the model number, such as the drive D2-0423-S-B-0 and motor FRLS4020106A.

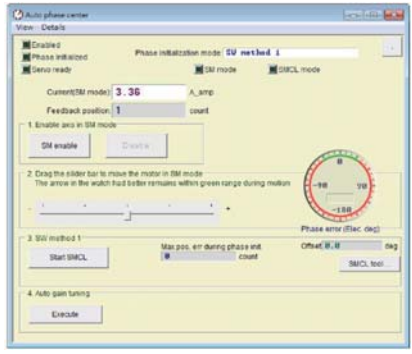


Fig. 4-26 Auto phase center screen (SW method 1)

SW method 5

This method is used in conjunction 13-bit digital incremental encoders. No hall sensor is needed for successful phase initialization. A phase angle self-inspection mechanism is added to the initialization process. This takes more time to finish the phase initialization because of the required current changes and phase angle self-inspection mechanism.

This method is used in conjunction with drives that have 0 in the ninth digit of the model number, and with motor that have 1 in the ninth digit of the model number, such as the drive D2-0423-S-B-0 and motor FRLS4020106A.

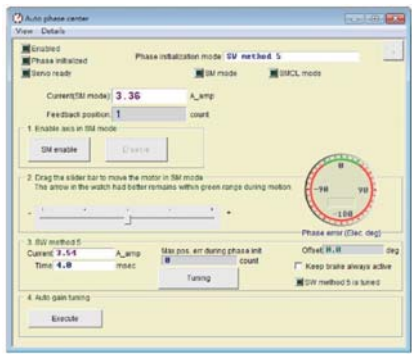


Fig. 4-27 Auto phase center screen (SW method 5)

SW method 3

This mode is used in the phase initialization of 17-bit digital incremental encoders. No tuning is needed for a successful phase initialization and the motor will not shudder during the initialization process.

This mode is used in conjunction with drives that have 4 in the ninth digit of the model number, and with motors that have 3 in the ninth digit of the model number, such as the drive D2-0423-S-B-4 and motor FRLS4020306A.

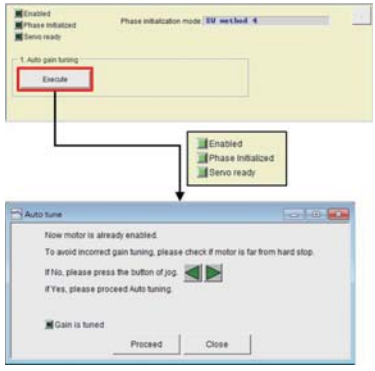
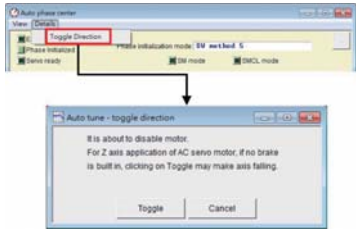
Fig. 4-28 Auto phase center screen (SW method 3)

4.3.2 Pre-operation for auto phase initialization

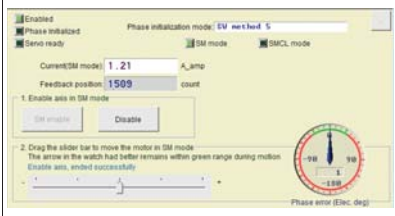
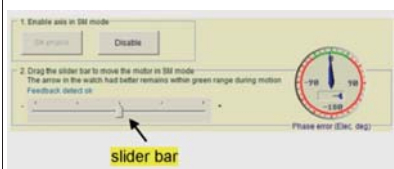
※ Confirm the connection to the motor is correct.
※ Confirm the encoder signal is correct.
※ Confirm the drive can receive the hardware excitation signal (‘Hardware Enable’)
※ Confirm if the motor overheat signal is connected.
※ Confirm the AC mains power has been turned on.

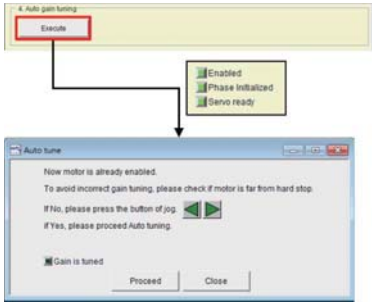
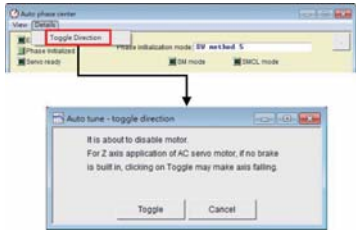
4.3.3 Auto phase initialization setup procedure

4.3.3.1 SW method 4

Step	Graphical (HMI) description	Operation
1		Phase initialization method: If user select that motor of model number ninth digit is 5. Lightening will automatically sets SW method 4.
2		Phase initialization and auto tune: Click the 'Execute' button, as in the left figure, to start the phase initialization. The 'auto tune' window pops up when the initialization is complete. Use ◀ and ▶ to drive the motor and keep it operating continuously. Confirm that the motor has moved far from the stop. After the motor has moved, click the 'Proceed' button to start the auto tune. Click the 'Close' button to close the window after the tuning has been completed. Now the auto phase initialization is complete and test run functions can be performed. ※ Note: Hard ware enable needs to be triggered for this step. ※ Note: Observe whether the Phase Initialized and Servo ready lights are green to check if the phase initialization was executed successfully and if the servo close-loop control is readv. ※ Note: The Gain is tuned status indicator flashes green during the auto gain process. The auto tuning is complete when it is continuously lit green or not continuously lit red. In this case, close the auto tune window and repeat Step 2.
3		Motion direction definition and setting the inverse direction: If after executing the continuous motion in Step 2 the direction of the motor is opposite that defined by users, close the auto tune window and open the window as shown in the left figure. Next click the 'Toggle' button in the window to set the inverse direction and carry out Step 2 again. ※ Note: If the motor is used in a vertical application and there is a braking mechanism, the motor will be de-excited if the direction of the motion is set to opposite. This may have a slide down effect.

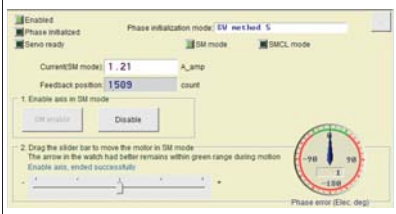
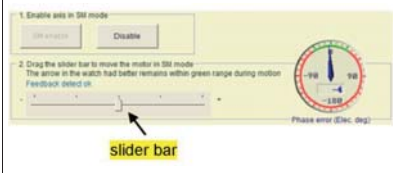
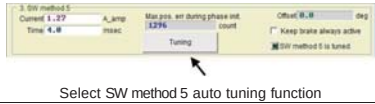
4.3.3.2 SW method 1

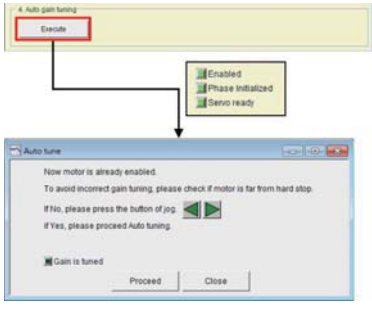
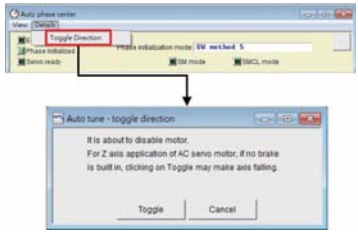
Step	Graphical (HMI) description	Operation
1		Phase initialization method: If a motor is used in conjunction with a 13-bit digital incremental encoder, lightening will automatically set SW method 5. In this case, user also can select SW method 1 from dropdown list.
2		SM mode excitation: Click the 'SM enable' button and the 'Enabled' indicator will turn green. ※ Note: When the motor is excited in SM mode, the drive outputs the current continuously as set in the 'Current' (SM mode) field. Hence excitation in the SM mode should not last too long to avoid overheating the motor. ※ Note: The exciting signal of the host controller needs to be triggered for this step.
3		Testing the direction of the motion in SM mode: Drag the slider bar to the left and right. The motor should rotate when the slider bar is dragged. The normal direction is to the right side and the inverse direction is to the left side. Normally the Phase error (Elec. deg) arrow lies inside the green area (-30 to +30 degrees). After releasing the slider bar, the message 'Feedback detect OK' will appear on the screen in Step 2 showing that this step is complete. If the arrow moves randomly, release the slider bar and then try to drag it again. ※ Note: If the arrow still moves randomly after dragging the slider bar again, please confirm the following: 1. The motor power line and the encoder feedback signal line are correctly connected. 2. The encoder settings and the parameter settings of the motor are correct. Go to the Configuration Center to check if the parameter settings (such as the resolution of the encoder and the pole-pair counts of the motor) are correct. ※ Note: The exciting signal of the host controller needs to be triggered for this step.

4		Phase initialization and auto tune: Click the 'Execute' button, as in the left figure, to start the phase initialization. The 'auto tune' window pops up when the initialization is complete. Use ◀ and ▶ to drive the motor and keep it operating continuously. Confirm that the motor has moved far from the stop. After the motor has moved, click the 'Proceed' button to start the auto tune. Click the 'Close' button to close the window after the tuning has been completed. Now the auto phase initialization is complete and test run functions can be performed. ※ Note: The exciting signal of the host controller needs to be triggered for this step. ※ Note: Observe whether the Phase Initialized and Servo ready lights are green to check if the phase initialization was executed successfully and if the servo close-loop control is ready. ※ Note: The Gain is tuned status indicator flashes green during the auto gain process. The auto tuning is complete when it is continuously lit green or not continuously lit red. In this case, close the auto tune window and repeat Step 4.
5		Definition of the motion direction and setting of the inverse direction: If after execution of the continuous motion in Step 4, the direction of the motion defined for the motor is found opposite to the direction defined by users, close the Auto tune window and open the window as shown in the left figure. Then click the Toggle button in the window to set the inverse direction and carry out Step 4 again. ※Note: If the motor is used in a vertical axis application and there is a braking mechanism, the motor will be de-excited if the direction of the motion is set opposite. This may have a slide down effect.
6		Phase initialization and performance tuning: This method only needs a slight movement of the motor to execute the phase initialization. The performance of the initialization is adapted along with the auto tune in Step 4. The result of the tuning can be confirmed in the following four steps: 1. Click the 'Start SMCL' button to perform the motor angle searching

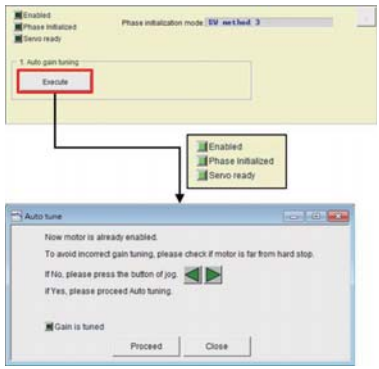
		test. 2. Observe the values in the 'Offset' and 'Max.pos.err during phase init.' fields. These indicate the motor angle searching result and the maximum displacement during the search respectively. 3. Repeat Steps 1 and 2 and observe if the error of the offset value in each repeat is within +/-15 deg. 4. If the error of the offset value is excessively high in each repeat, click the 'SMCL tool…' button for advanced tuning. Please refer to Appendix A. ※ Note: The exciting signal of the host controller needs to be triggered for this step.

4.3.3.3 SW method 5

Step	Graphical (HMI) description	Operation
1		Phase initialization method setting: If a motor is used in conjunction with a 13-bit digital incremental encoder, lightening will automatically set SW method 5.
2		SM mode excitation: Click the 'SM enable' button and the 'Enabled' indicator will turn green. ※ Note: When the motor is excited in SM mode, the drive outputs the current continuously as set in the 'Current' (SM mode) field. Hence excitation in the SM mode should not last too long to avoid overheating the motor. ※ Note: The exciting signal of the host controller needs to be triggered for this step.
3		Testing the direction of the motion in SM mode: Drag the slider bar to the left and right. The motor should rotate when the slider bar is dragged. The normal direction is to the right side and the inverse direction is to the left side. Normally the Phase error (Elec. deg) arrow lies inside the green area (-30 to +30 degrees). After releasing the slider bar, the message 'Feedback detect OK' will appear on the screen in Step 2 showing that this step is complete. If the arrow moves randomly, release the slider bar and then try to drag it again. ※ Note: If the arrow still moves randomly after dragging the slider bar again, please confirm the following: 1. The motor power line and the encoder feedback signal line are correctly connected. 2. The encoder settings and the parameter settings of the motor are correct. Go to the Configuration Center to check if the parameter settings (such as the resolution of the encoder and the pole-pair counts of the motor) are correct. ※ Note: The exciting signal of the host controller needs to be triggered for this step.
4	 Select SW method 5 auto tuning function	SW method 5 auto tuning function: Click the 'Tuning' button, as in the left figure, to automatically adapt the current value for phase initialization. The maximum value shall not be greater than the peak current of the

		motor. ※ Note: The exciting signal of the host controller needs to be triggered for this step. ※ Note: SW method 5 may cause noise during the operation and auto tuning; this is normal. The higher the current, the higher the noise will be. It may also change depending on the mechanisms used and the load intensity.
5		Phase initialization and auto tune: Click the 'Execute' button, as in the left figure, to start the phase initialization. The 'auto tune' window pops up when the initialization is complete. Use ◀ and ▶ to drive the motor and keep it operating continuously. Confirm that the motor has moved far from the stop. After the motor has moved, click the 'Proceed' button to start the auto tune. Click the 'Close' button to close the window after the tuning has been completed. Now the auto phase initialization is complete and test run functions can be performed. ※ Note: The exciting signal of the host controller needs to be triggered for this step. ※ Note: Observe whether the Phase Initialized and Servo ready lights are green to check if the phase initialization was executed successfully and if the servo close-loop control is ready. ※ Note: The Gain is tuned status indicator flashes green during the auto gain process. The auto tuning is complete when it is continuously lit green or not continuously lit red. In this case, close the auto tune window and repeat Step 5.
6		Motion direction definition and setting the inverse direction: If after executing the continuous motion in Step 4 the direction of the motor is opposite that defined by users, close the auto tune window and open the window as shown in the left figure. Next click the 'Toggle' button in the window to set the inverse direction and carry out Step 5 again. ※ Note: If the motor is used in a vertical application and there is a braking mechanism, the motor will be de-excited if the direction of the motion is set to opposite. This may have a slide down effect.

4.3.3.4 SW method 3

Step	Graphical (HMI) description	Operation
1		Phase initialization method : If a motor is used in conjunction with the drive that has 4 in the ninth code of the model number and a 17-bit digital incremental encoder, and the ninth digit of its model number is 3, the system automatically sets the phase initialization method to SW method 3.
2		Phase initialization and auto tune: Click the 'Execute' button, as in the left figure, to start the phase initialization. The 'auto tune' window pops up when the initialization is complete. Use ◀ and ▶ to drive the motor and keep it operating continuously. Confirm that the motor has moved far from the stop. After the motor has moved, click the 'Proceed' button to start the auto tune. Click the 'Close' button to close the window after the tuning has been completed. Now the auto phase initialization is complete and test run functions can be performed. ※ Note: The exciting signal of the host controller needs to be triggered for this step. ※ Note: Observe whether the Phase initialized and Servo ready lights are green to check if the phase initialization was executed successfully and if the servo close-loop control is ready. ※ Note: The Gain is tuned status indicator flashes green during the auto gain process. The auto tuning is complete when it is continuously lit green or not continuously lit red. In this case, close the auto tune window and repeat Step 2.
3		Motion direction definition and setting the inverse direction: If after executing the continuous motion in Step 2 the direction of the motor is opposite that defined by users, close the auto tune window and open the window as shown in the left figure. Next click the 'Toggle' button in the window to set the inverse direction and carry out Step 2 again. ※ Note: If the motor is used in a vertical application and there is a braking mechanism, the motor will be de-excited if the direction of the motion is set to opposite. This may have a slide down effect.

4.3.4 Instructions for auto phase initialization

4.3.4.1 Excited current (SM mode)

Output current (SM mode) setting:

Both the default value and the upper value are 95% of the continuous current. To ensure the operation with this current in SM mode, the static and dynamic friction must be assured to allow smooth operation of the motor without the position excessively falling behind.

If the static friction temporarily becomes dynamic friction when starting SM mode, or if the dynamic friction temporarily becomes static friction when stopping SM mode, the motor shudder as a result. This does not indicate that the drive has any problems.

4.3.4.2 Troubleshooting the motion direction test in SM mode

※ Make sure that the motor power line and the feedback signal line of the encoder has been correctly connected.

※ Make sure that the settings of the encoder and parameter settings of the motor are correct, such as the resolution of the encoder or the pole-pair counts of the motor.

※ Make sure that the encoder uses a differential signal.

※ Make sure that the grounding system is suitable.

4.3.4.3 Troubleshooting the motor motion

※ Make sure that the exciting signal of the host controller has been triggered.

※ Make sure that the drive software excitation has been executed.

※ Make sure that there is no mechanical interference.

※ Make sure the power line of the motor is connected correctly.

※ Make sure that the resistance of the motor is correct.

4.4 I/O Center

4.4.1 Digital inputs and their functions

Click in the main function keys area in the main screen to open the I/O Center. Click the dropdown button ( ) in the input function menu to select the digital input pin and its function, as shown in Fig. 4-29.

Fig. 4-29 Input function menu

Status indicator
The corresponding input pin has been enabled if the status indicator is lit green. The input pin has not been enabled if the indicator remains off.

Logic inversion setting (Invert)
When 'Invert' is checked, the trigger condition will be inverted.

Symbol	Input function	Description	Trigger
SVN	Axis Enable	Excitation/de-excitation for I3 by default, with edge trigger as the activating condition	Level Trigger
LL	Left Limit Switch	Hardware left limit for I6 by default	Level Trigger
RL	Right Limit Switch	Hardware right limit for I9 by default	Level Trigger
MAP	Home OK, Start Err. Map	The homing okay command from the host controller	Edge Trigger
RST	Reset Amplifier	Drive reset	Edge Trigger
DOG	Near Home Sensor	Near home sensor	Level Trigger
CE	Clear Error	Clear error	Edge Trigger
INVC	Invert Command	Inversion of the analog voltage command in velocity or force/torque mode	Level Trigger
GNS	Switch to Secondary CG	Switch to secondary common grain	Level Trigger
JSEL	Switch to Secondary VPG	Switch to secondary VPG gain	Level Trigger
ZSC	Zero Speed Clamp	When this signal is received in velocity mode, and the speed is lower than the setting value, the motor servo will be locked in a fixed position	Level Trigger
INH	Inhibit Pulse Command	Inhibit pulse command	Level Trigger
PSEL	Switch HI/LO Pulse Input	Switch high/low speed pulse input channels	Level Trigger
EMG	Abort Motion	The motor enters the emergency stop procedure after receiving this signal during operation	Level Trigger
CPE	Clear Position Error	Clear position error	Level Trigger
MOD	Switch to Secondary Mode	Switch from the primary to the secondary operation mode	Level Trigger
HOM	Start Homing	Start the built-in homing procedure of the drive	Edge Trigger
DIV1	Electronic Gear Select (DIV1)	Selection of the electronic gear ratio in pulse mode	Level Trigger
DIV2	Electronic Gear Select (DIV2)	Selection of the electronic gear ratio in pulse mode	Level Trigger

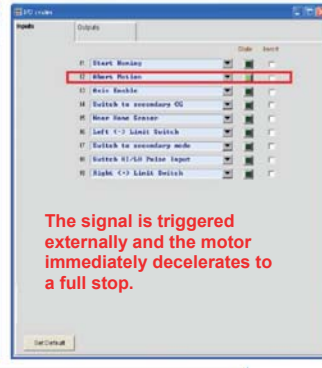
Table 4-2 D2Drive Input default settings

Pin	Signal	Specified signal input				Inversion
		Stand-Alone mode	Position mode	Velocity mode	Force/torque mode	
33	I1	Start Homing	Inhibit Pulse Command	Zero Speed Clamp	Zero Speed Clamp	No
30	I2	Abort Motion	Clear Position Error			No
29	I3	Axis Enable	Axis Enable	Axis Enable	Axis Enable	No
27	I4	Switch to secondary CG	Switch to secondary CG	Switch to secondary CG	Switch to secondary CG	No
28	I5	Near Home Sensor	Electronic Gear Select <DIV1>			No
26	I6	Left (-) Limit Switch	Left (-) Limit Switch	Left (-) Limit Switch	Left (-) Limit Switch	No
32	I7	Switch to Secondary Mode	Switch to Secondary Mode	Switch to Secondary Mode	Switch to Secondary Mode	No
31	I8	Clear Error	Clear Error	Clear Error	Clear Error	No
9	I9	Right (+) Limit Switch	Right (+) Limit Switch	Right (+) Limit Switch	Right (+) Limit Switch	No

Input Function	Abort Motion		Operation mode		Pos	Vel	Trq	Std
Symbol	EMG	Default Input No.	I2	Circuit diagram	Refer to 3.5.2			

Function description:
User can use his host controller to trigger this input signal of D2 under position, velocity or Stand-Alone mode.. The drive will decelerate the motor to stop as a result of the emergency stop function. (The deceleration value for the emergency stop can be set in the 'Dec. kill' field in the Performance Center.)

Instructions for use:
Users selects 'Abort Motion' (I2 by default) in the 'Inputs' tab of the I/O Center. The signal is triggered externally to immediately decelerate the motor to a full stop.



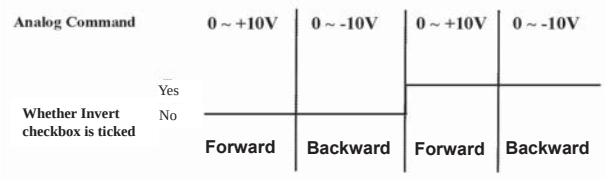
When the input point of the Abort Motion is 'true' (indicator on), the external pulse command is ignored and the drive decelerates the motor as a result of the emergency stop function ('Dec. kill').

Input Function	Invert Command		Operation mode		Pos	Vel	Trq	Std
Symbol	INVC	Default Input No.	None	Circuit diagram	Refer to 3.5.2			

Function description:
This inverts the command from the host controller.

Instructions for use:
Specify the 'Invert Command' as the input function in velocity or force/torque mode. When Invert checkbox is not ticked, positive voltage means forward motion and negative voltage means backward motion.

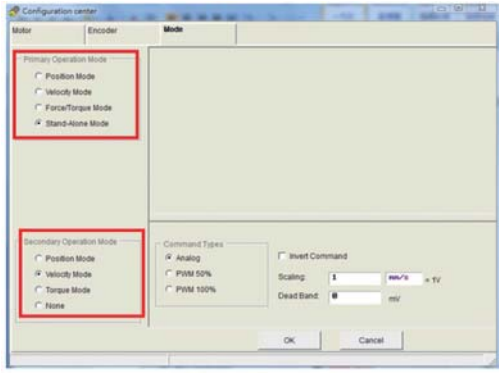
When Invert checkbox is ticked, voltages have opposite meaning.



Input Function	Switch to Secondary Mode		Operation mode		Pos	Vel	Trq	Std
Symbol	MOD	Default Input No.	I7	Circuit diagram	Refer to 3.5.2			

Function description:
This enables users to switch the mode using the I/O signal from the host controller.

Instructions for use:
User can set the modes in the 'Mode' tab of the Configuration Center as shown in the figure below.



When the input point State indicates off, "Primary Operation Mode" is activated. When the input point State indicates on, "Secondary Operation Mode" is activated. Green is on and dark is off.

Input Function	Electronic Gear Select (DIV1, DIV2)		Operation mode		Pos	Vel	Trq	Std
Symbol	DIV1, DIV2	Default Input No.	I5	Circuit diagram	Refer to 3.5.2			

Function description:
This enables users to switch between four sets of electronic gear ratios.

Instructions for use:
Fig. 1 and Fig. 2 show the settings for electronic gear selections. There are four gear ratios that can be set. User can use input points to select the desired gear ratio according to the DIV0 and DIV1 input states.

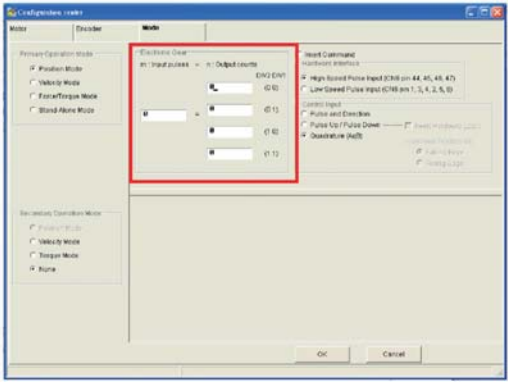


Fig. 1 Electronic gear settings screen (Primary Operation Mode)

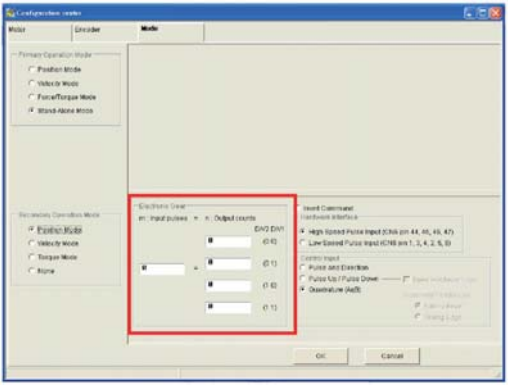


Fig. 2 Electronic gear settings screen (Secondary Operation Mode)

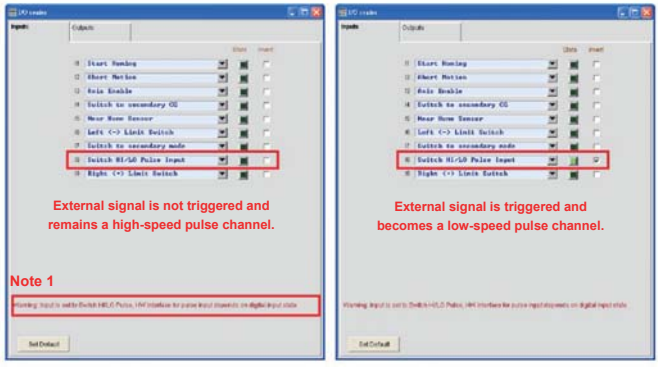
The desired electronic gear ratios are selected from different combinations of DIV1 and DIV2. The corresponding combinations are shown in the table below.

DIV2	DIV1	Numerator
0	0	1st
0	1	2nd
1	0	3rd
1	1	4th

Input Function	Switch HI/LO Pulse Input		Operation mode		Pos	Vel	Trq	Std
Symbol	PSEL	Default Input No.	None	Circuit diagram	Refer to 3.5.2			

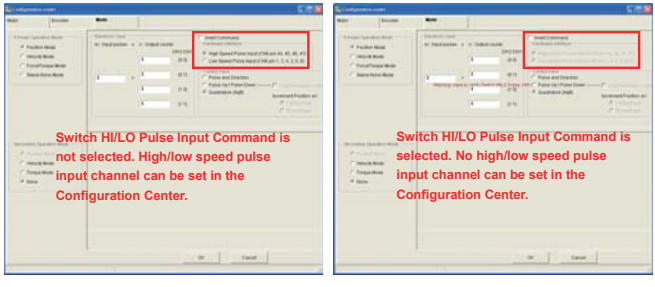
Function description:
This enables users to trigger the input signal via the host controller to switch high/low speed pulse input channels.

Instructions for use:
users can select 'Switch HI/LO Pulse Input Command' (as in the figure below) in the 'Inputs' tab of the I/O Center. (I1 to I9 are selectable; the following figures show I8 as an example.) The high/low speed pulse input channel is switched by an external trigger signal.


External signal is not triggered and remains a high-speed pulse channel.
External signal is triggered and becomes a low-speed pulse channel.
Note 1

High speed channel of pulse input is engaged when the input point signal is off. Low speed channel of pulse input is engaged when the input point signal is on. Green is on and dark is off.

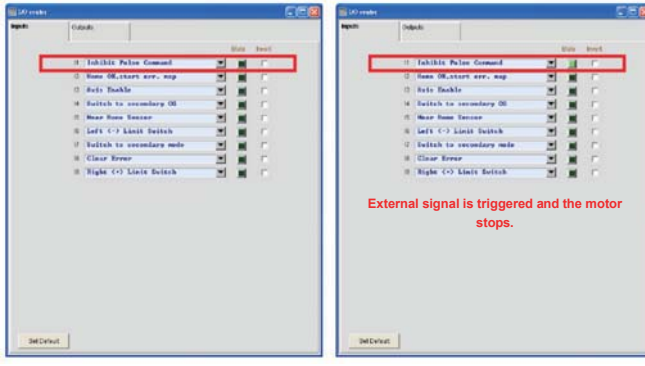
Note 1. If any one of the input points (I1~I9) is configured as Switch HI/LO Pulse Input, the settings for hardware interface in Configuration center will be irrelevant.


Switch HI/LO Pulse Input Command is not selected. High/low speed pulse input channel can be set in the Configuration Center.
Switch HI/LO Pulse Input Command is selected. No high/low speed pulse input channel can be set in the Configuration Center.

Input Function	Inhibit Pulse Command		Operation mode		Pos	Vel	Trq	Std
Symbol	INH	Default Input No.	I1	Circuit diagram	Refer to 3.5.2			

Function description:
This enables users to inhibit the reception of pulse commands from the host controller by triggering the input signal.

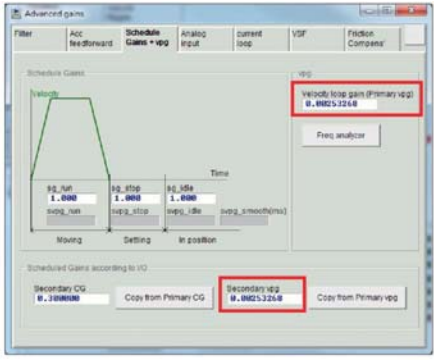
Instructions for use:
When users specifies 'Inhibit Pulse Command' as the input function in pulse mode, reception of pulse commands from the host controller will be prohibited when a 'true' signal is received. The drive will receive pulse commands from the host controller to drive the motor when a 'false' signal is received.



Input Function	Switch to Secondary VPG		Operation mode		Pos	Vel	Trq	Std
Symbol	JSEL	Default Input No.	None	Circuit diagram	Refer to 3.5.2			

Function description:
This enables users to switch between velocity loop gains.

Instructions for use:
Users can set the input function in the ‘Schedule Gains + vpg’ tab in ‘Advanced gains’, as shown in the figure below.

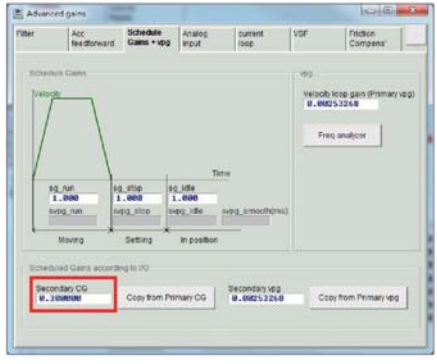


When the input point State is on, Secondary vpg is used. When off, Primary vpg is used.

Input Function	Switch to Secondary CG		Operation mode		Pos	Vel	Trq	Std
Symbol	GNS	Default Input No.	None	Circuit diagram	Refer to 3.5.2			

Function description:
This enables users to switch between CGs.

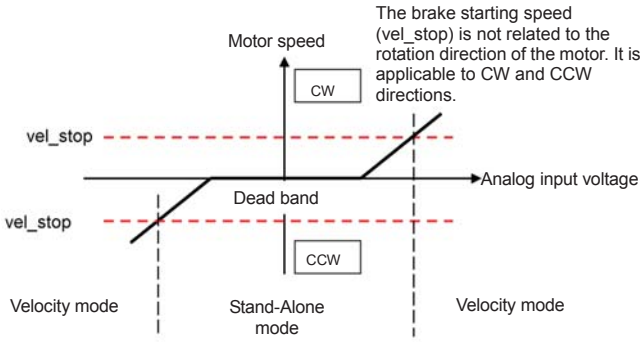
Instructions for use:
Users can set the input function in the ‘Schedule Gains + vpg’ tab in ‘Advanced gains’, as shown in the figure below.



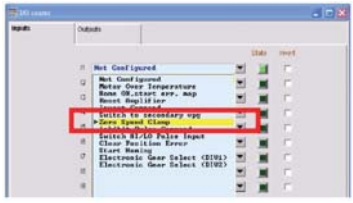
When the input point State is on, Secondary CG is used. When off, Primary CG is used.

Input Function	Zero Speed Clamp		Operation mode		Pos	Vel	Trq	Std
Symbol	ZSC	Default Input No.	I1	Circuit diagram	Refer to 3.5.2			

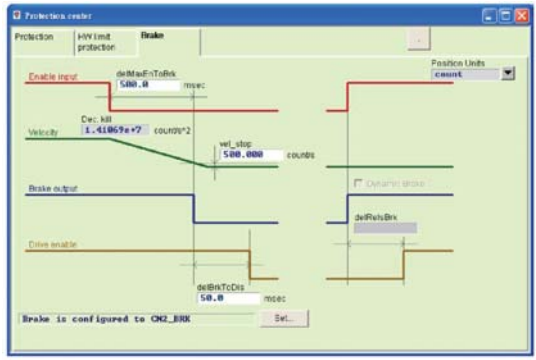
Function description:
This input function is only applicable to velocity mode and is level triggered. This input function is only applicable to velocity mode and is level triggered. When the input point State is on, motor will be immediately servo locked, when the velocity command decreased below the vel_stop threshold. If velocity command become above the threshold, it starts running again according to the command. Please refer to the figure below.



Instructions for use:
In velocity mode, enter the I/O Center and set the 'Zero Speed Clamp' as the input function. Please refer to the figure below (with I1 as an example):



Next enter the ‘Protection Center’ and set the brake starting speed (vel_stop) to a suitable value (500 count/s by default). Please refer to the figure below.



Zero Speed Clamp will be activated when State of I1 is on.

Input Function	Clear Position Error		Operation mode		Pos	Vel	Trq	Std
Symbol	CPE	Default Input No.	None	Circuit diagram	Refer to 3.5.2			

Function description:
This allows resetting the Position Error value back to 0.

Instructions for use:
The Position Error value will be reset to 0 when the input state of the 'Clear Position Error' is on. Green is on and dark is off.

Input Function	Clear Error		Operation mode		Pos	Vel	Trq	Std
Symbol	CE	Default Input No.	I8	Circuit diagram	Refer to 3.5.2			

Function description:
This allows error states to be cleared.

Instructions for use:
Error messages will be cleared when the input state of 'Clear Error' is on. Green is on and dark is off.

Input Function	Start Homing		Operation mode		Pos	Vel	Trq	Std
Symbol	HOM	Default Input No.	I1	Circuit diagram	Refer to 3.5.2			

Function description:
This allows the execution of the homing action.

Instructions for use:
The homing action will be executed using the homing method set in the Application Center when the input state of 'Start Homing' is changed from off to on. Green is on and dark is off.

Default function setting

Click the 'Set Default' (Set Default) button to set all "input functions" to the factory default settings. The message window "Set Default Input States Configuration" appears after clicking the button, and all input functions will be changed to the factory default settings after clicking OK (確定), as shown in Fig. 4-30.

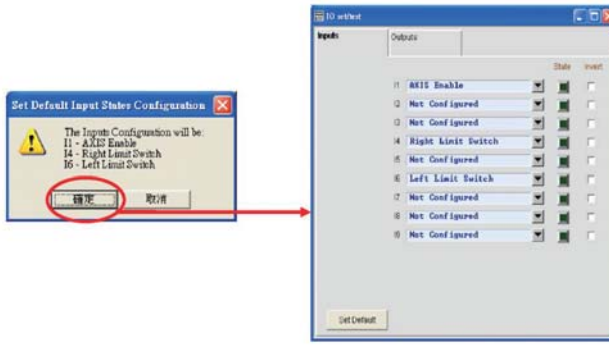


Fig. 4-30 Input default values

Status indicator

The corresponding input pin has been engaged if the status indicator is lit green. The input pin has not been engaged if the indicator remains off.

Logic inversion setting (Invert)

When 'Invert' is checked, the trigger condition will be inverted.

4.4.2 Digital outputs and their functions

The drive provides five sets of programmable digital outputs. Four of them (O1-O4) are general purpose outputs (CN 6 connector) and the fifth output (CN2BRK) is specially designed as a brake output or used as a general purpose output.

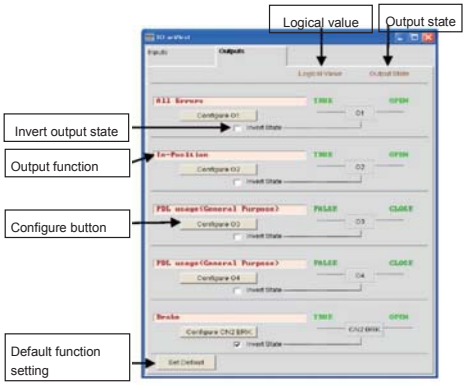


Fig. 4-31 Digital output

Logical value
The logical value of each output signal is displayed here. The value is indicated as ‘True’ or ‘False’.
Output function
When any item in the configuration function menu is checked, the name of the item will be displayed in the status display field. If two or more items are checked, "Customized" will be displayed. If all error items are checked (as shown in Fig. 4-31), "All Errors" will be displayed. If no items are checked, "PDL usage (General Purpose)" will be displayed for general purpose output and the output function can then be controlled by PDL program language.
Output state
The output pin state of the drive is displayed here as CLOSE or OPEN (transistor conducting or non-conducting). In this way, users can understand the state of the hardware signal that the drive outputs and use this to identify wiring errors.
Invert output state
If required, this option can be checked to invert the polarity of the output state. Please note that the internal logical value of the drive will not be affected by the invert output setting.
Output function setting
Every output port (O1-O4) has a corresponding ‘Configure Setting’ button. Click the ‘Configure O1’ (Configure O1) button to open the ‘Configuration Setting’ window. This menu provides categories for ‘Statuses’, ‘Errors’ and ‘Warnings’ (Fig. 4-32). If users selects two or more items in the same configuration, the output function works when one of the items is triggered. Users can click the ‘Not Configured’ (Not Configured) button to cancel all checked options. After selecting the desired function, users needs to click ‘Apply’ (Apply) to save the settings or click ‘Cancel’ (Cancel) to discard any changes. As for the ‘Set all errors’ (Set all errors) button in the ‘Errors’ category, it is recommended to use this button to quickly select all errors. This is helpful for users to finish the settings more quickly.

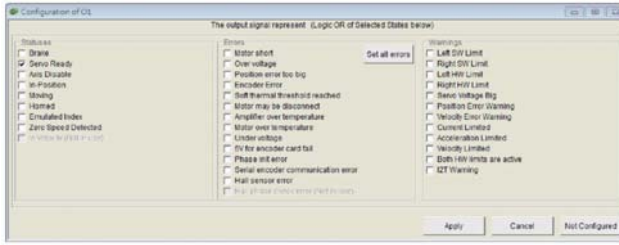


Fig. 4-32 Input and output function settings

Symbol	Output function	Description
Statuses		
BRK	Brake	Brake signal (This setting is exclusive. No other options in Statuses, Errors or Warnings can be selected after this is checked.)
RDY	Servo Ready	Servo is ready
DIS	Axis Disable	Servo is off
INP	In-Position	In-Position signal
MOV	Moving	In a moving state
HOMD	Homed	Homing completed
EMI	Emulated Index	Emulation of Z phase index signal
ZSPD	Zero Speed Detected	Zero speed detection signal
Errors		
ALM	Errors	All errors are normally checked (by clicking the 'Set all error' button), but users can change the error combinations to meet their actual requirements.
Warnings		
LS	Left Software Limit	Trigger software left limit
RS	Right Software Limit	Trigger software right limit
LH	Left Hardware Limit	Trigger hardware left limit
RH	Right Hardware Limit	Trigger hardware right limit
SVB	Servo Voltage Big	PWM command greater than threshold
PEW	Position Error Warning	Position error greater than the warning setting value
VEW	Velocity Error Warning	Velocity error greater than the warning setting value
CUL	Current Limited	Current has been saturated; motor peak current specification value
ACL	Acceleration Limited	Motor operation has reached the acceleration protection setting
VL	Velocity Limited	Motor operation has reached the velocity protection setting
BOHL	Both HW limits are active	Both left and right hardware limits have been triggered

Default function setting

Click the 'Set Default' (Set Default) button to set all output functions to the factory default settings. Click the OK 確定 button to display the "Set Default Output States Configuration" message window and then click OK to return to the factory default values (Fig. 4-33). O1 is the default value for the selection of all 'Errors' options, O2 is the 'In-Position' signal, and CN2BRK is the default value for the brake.

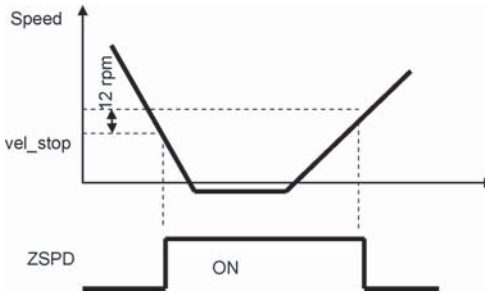
Fig. 4-33 Output default values

Table 4-3 D2 Drive Output default settings

Pin	Signal	Specified signal input				Inversion
		Stand-Alone mode	Position mode	Velocity mode	Force/torque mode	
34、35	O1	Servo Ready	Servo Ready	Servo Ready	Servo Ready	No
36、37	O2	Errors	Errors	Errors	Errors	No
38、39	O3	In-Position	In-Position			No
10、11	O4	Zero Speed Detected	Zero Speed Detected	Zero Speed Detected	Zero Speed Detected	No
2	CN2 BRK	Brake	Brake	Brake	Brake	No

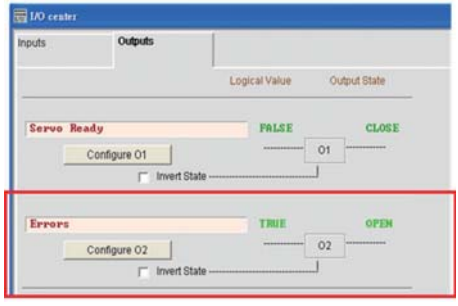
<table>
<tr><td>Input Function</td><td colspan="2">Zero Speed Detected</td><td colspan="2">Operation mode</td><td>Pos</td><td>Vel</td><td>Trq</td><td>Std</td></tr>
<tr><td>Symbol</td><td>ZSPD</td><td>Default Input No.</td><td>O4</td><td>Circuit diagram</td><td colspan="4">Refer to 3.5.3</td></tr>
<tr><td colspan="9">Function description:
The signal is outputted when the motor speed is approaching zero.

Instructions for use:
The speed approaching zero means that the movement speed of the motor is lower than the threshold value set by the ‘vel_stop’ parameter. This function provides a 12 rpm delay to avoid ZSPD output signal bouncing. For more information about ‘vel_stop’, please refer to 7.3.2 under 7.3 Brake output.

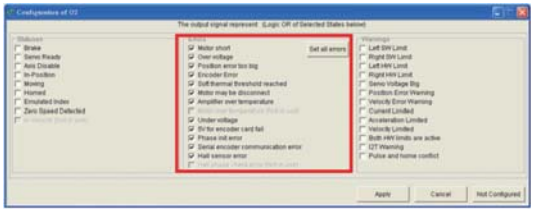
 
</td></tr>
</table>

Input Function	Errors		Operation mode		Pos	Vel	Trq	Std
Symbol	ALM	Default Input No.	O2	Circuit diagram	Refer to 3.5.3			

Function description: This provides an error output status for users.
Instructions for use: Users can set the availability of 'Errors' in the 'Outputs' tab of the I/O Center (O2 by default).



Click 'Configure O2' to open the 'Configuration of O2' settings window. Click 'Set all errors' to check all the options in the 'Errors', as shown highlighted in red in the figure below. In this example, the output currently indicates all available errors. If users does not select all error options, but only part of them, the output currently used indicates 'Customized'.



Trigger method: Level trigger

4.5 In-Position setting

4.5.1 Function overview

In the servo system, both the target position and encoder feedback position have a position error. A setting period (or setting time) is needed for the motor to enter the target radius when it moves to the target position. The D2 drive provides an In-Position settings interface. This enables users to observe if the motor reaches the target position by setting the target radius and debounce time. This status can be sent to the host controller in the form of a digital signal.

4.5.2 Settings

Click to enter the Performance Center. The In-Position settings screen is displayed in the 'Position' tab. Users can click the "Set scope…" (Set scope...) button to capture the waveform, if needed, from the scope window. The in-position signal is used by O2 by default. Please refer to 4.4.2 for digital output settings.

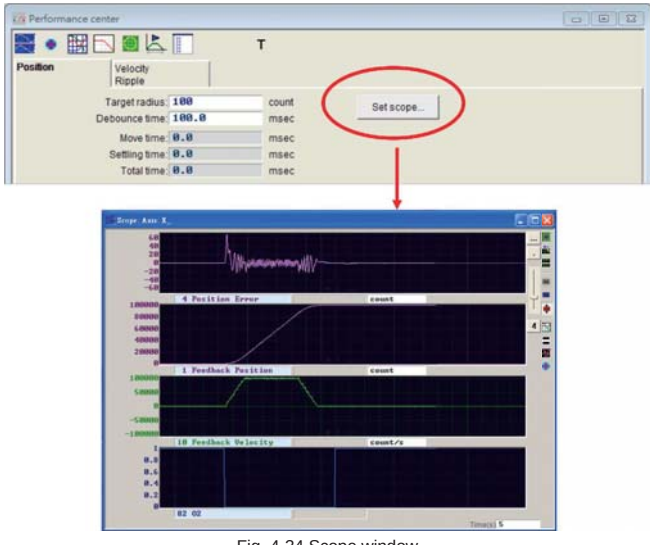


Fig. 4-34 Scope window

Table 4-4

Parameter name	Description
Target radius	In-Position is confirmed if the error is within the target radius setting. The default value is 100 times the resolution of the encoder.
Debounce time	In-Position is not confirmed until the error keep under target radius for a preset debounce time after entering the In-Position target radius.
Move time	Route planning time
Setting time	Setting time
Total	Total time (move time + setting time)

4.6 Parameter overview and configuration of mode

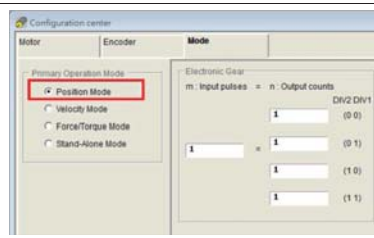
4.6.1 Position mode

The host controller sends a pulse to the drive, and this pulse is similar to position command, thus the drive moves a corresponding distance when it receives a pulse. The host controller is responsible for planning the route. The pulse is sent more quickly on acceleration, and is sent at a fixed frequency on constant speed.

4.6.1.1 Basic setting of position mode

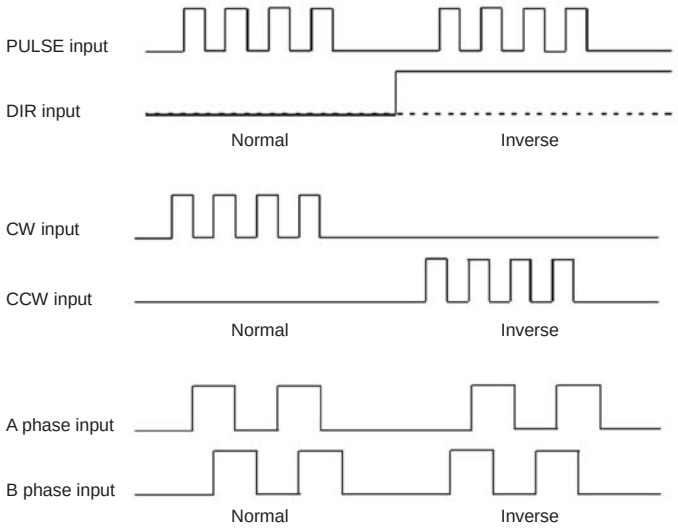
The basic setting of the position mode is described below.

Step 1: Mode selection
The steps for selecting the position mode via HMI are described below.

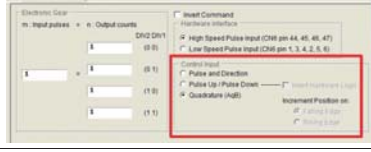
Step	Graphical (HMI) description	Operation
1		Execute the Lightening HMI Program
2		Click the Configuration Center icon (as shown on the left) in the main function tool bar of the HMI, or select the Configuration Center option from “Conf/Tune” in the function menu.
3		In the Configuration Center, select the “Mode” tab, as show n the left figure)
4		In the mode operation page, select ”Position Mode”, as show on the on the left figure)

Step 2: Selecting the pulse format

The pulse is generated in three formats: Pulse/Dir, Pulse Up/Pulse Down or CW/CCW, and AqB phase (Quadrature) square wave as shown in the figure below.



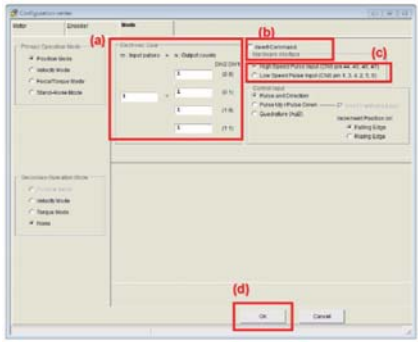
The steps for selecting the pulse format via HMI are described below.

Step	Graphical (HMI) description	Operation
1		In the Mode operation page, select the pulse format on the “Control Input” for the requirement, as shown on the left figure.
2		Select the pulse command trigger method on “Increment Position On” for the requirement, as show on the left figure. (Note: This setting is only needed when ‘Pulse and Direction’ or ‘Pulse Up/Pulse Down’ is selected)

Step 3: Electronic gear setting

The electronic gear can be set in the pulse mode. One input pulse normally corresponds to one encoder count. For example, the gear ratio is 2:3, means two input pulses correspond to three encoder counts. Total of four sets electronic gear radio can be set. They can be switched using two I/Os (DIV1 and DIV2). They can be switched using two I/Os (DIV1 and DIV2).

The steps for setting the electronic gear ratio via HMI are described below.

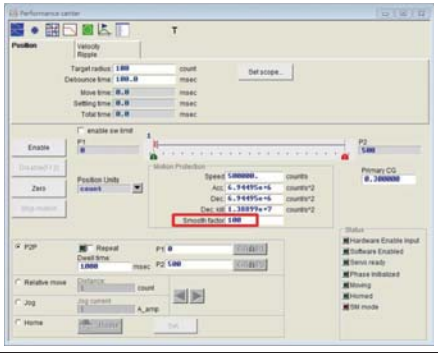
Step	Graphical (HMI) description	Operation
1		In the Mode operation page, set the electronic gear radio on “Electronic Gear” for the requirement, as show (a) on the left figure.
2		In the Mode operation page, select the pulse command invert on “Invert Command” for the requirement, as show (b) on the left figure.
3		In the Mode operation page, depending on the hardware wiring method, select high/low command pulse input on “Hardware Interface”, as show (c) on the left figure.
4		After finishing all the setting, click the “OK” button, as show on the left figure.
5		The parameter confirmation screen appear, click the “Send to RAM”, as show on the left figure.
6		Click the ‘Save to Flash’ button in the HMI main function tool bar to save the parameters in the flash memory. This will

		retain the parameters even if the drive is turned off.

Step 4: Smooth factor

Rapid increases or decreases in acceleration in a short period of time mean that the force on an object in motion can suddenly increase or decrease. Application of the smooth motion technique to the motion control loop is helpful for maintaining performance and reducing such impacts. The D2 drive uses a smooth factor to determine the S-curve or T-curve track and the adjustment range is 0-500. The track is closer to an S-curve with a higher adjustment value, and is closer to a T-curve with a lower adjustment value. A value of 1 means no smooth function is enabled. When a higher smooth factor is used, in some cases the reduced output force of the motor is helpful for the final settings during the positioning process. However, the move time will unavoidably increase when the motion becomes smoother. Tests on the machine are needed to adjust the smooth factor and reach a balance. The motion protection function can be disabled when the smooth factor is set to 0.

The steps for setting the smooth factor via HMI are described below.

Step	Graphical (HMI) description	Operation
1		Click the Performance Center icon (as shown on the left) in the main function tool bar of the main HMI window, or select the Performance Center option from 'Conf/Tune' in the function menu.
2		In the Performance Center, set Smooth factor for the requirement, as show on the left figure.

4.6.2 Velocity mode

The drive can receive commands from the host controller via voltage,named V commands. The input voltage ranges from +10V to -10V. The drive makes the received +10V to -10V input voltage correspond to the velocity or current control to drive the motor. In addition to the voltage, the host controller can send commands via PWM signals, named PWM commands. The PWM command converts corresponding to different velocity commands depending on the duty cycle. It is classified into single-wire type (PWM-50%) and two-wire (PWM-100%) type. The single-wire type (PWM-50%) type refers to the duty cycle of 50%. An inverse motion occurs when the duty cycle is less than 50%, while normal motion occurs when the duty cycle is more than 50%. The two-wire type (PWM-100%) needs one more pin to control the operation direction of the motor.

V command

The analog voltage signal is converted to a velocity command andthe drive controls the motor to operate at that velocity. The higher the voltage value, but it will not exceed the maximum speed set by drive.. Conversely, the lower the voltage value, the lower the output speed. When the voltage value is negative, the output speed becomes negative correspondingly and the motor operates inversely. The command speed to which the unit voltage corresponds can be set in the drive.

PWM Command

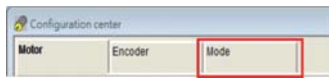
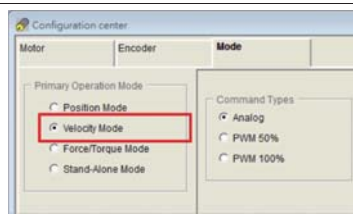
The PWM command is converted to a velocity command to directly control the operation speed of the motor. The velocity to which the Full PWM corresponds can be set in the drive.

4.6.2.1 Basic setting of velocity mode

The basic setting of the velocity mode is described below.

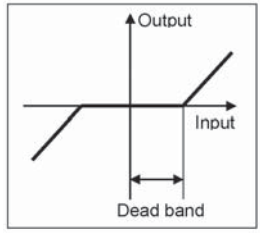
Step 1: Mode selection

The steps for selecting velocity mode via HMI are described below.

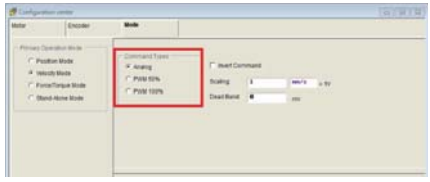
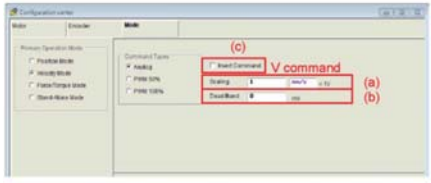
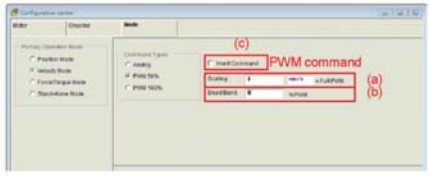
Step	Graphical (HMI) description	Operation
1		Execute the Lightening HMI program
2		Click the Configuration Center icon (as show on the left figure) in the main function tool bar of the HMI, or select the Configuration Center option from “Conf/Tune” in the function menu.
3		In the Configuration Center, select the ‘Mode’ tab (as shown on the left)-> In the Configuration Center, select the “Mode” tab, as show on the left figure
4		In the mode operation page, select ”Velocity Mode”, as show on the left figure.

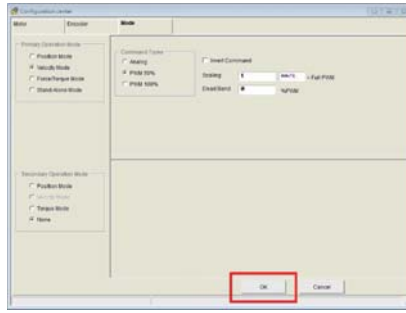
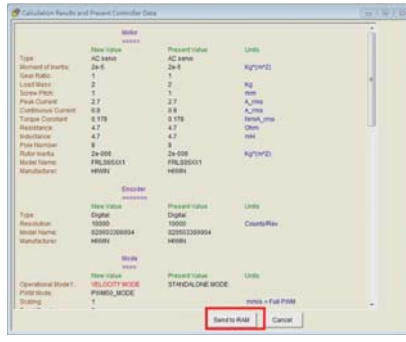
Step 2: Setting the command input format

Velocity mode can be selected if the host controller used can send analog command or PWM command. Only the Scaling between the external command and current has to be set for the force/torque mode. The unit shows the corresponding relationship of 1 V with mm/s or between the Full PWM and the highest speed. A dead band can be set for the velocity command. This will be zero when the input voltage or PWM is lower than this setting. Please refer to the figure below.



The steps for setting the command input format via HMI are described below.

Step	Graphical (HMI) description	Operation
1		In the mode operation page, key in the required command input format from the “Command Types”, as shown on the left figure.
2		In the mode operation page, set the scaling between external command and velocity for requirement. The unit shows the corresponding relationship of 1V with the mm/s or rpm, or between the Full PWM and the highest speed, as show (a) on the left figure.
3		Set the ‘Dead Band’ for the current command, as show (b) on the left figure.
4		Select “Invert Command” to invert voltage or PWM command for requirement

5		Select “Invert Command” to invert voltage or PWM command for requirement
6		The parameter confirmation screen appears; click the ‘Send to RAM’ button (as shown on the left)
7		Click the ‘Save to Flash’ button in the HMI main function tool bar to save the parameters in the flash memory. This will retain the parameters even if the drive is turned off.

4.6.3 Force/torque mode

The drive can receive commands from the host controller via voltage (known as V commands). The input voltage ranges from +10V to -10V. The drive makes the received +10V to -10V input voltage correspond to the velocity or current control to drive the motor. In addition to the voltage, the host controller can send commands via PWM signals (known as PWM commands).The PWM command converts to different velocity or current commands depending on the duty cycle. It is classified into single-wire (PWM-50%) and two-wire (PWM-100%) types. The single-wire (PWM-50%) type refers to the duty cycle of 50%. An inverse motion occurs when the duty cycle is less than 50%, while normal motion occurs when the duty cycle is more than 50%. The two-wire (PWM-100%) type needs one more pin to control the operation direction of the motor.

V command

The analog voltage signal is converted to a current command to directly control the current output of the drive and thus the force and torque of the motor. The higher the voltage value, the higher the controlled current output (but it will not exceed the upper limit set for the motor). The lower the voltage value, the lower the controlled current output. When the voltage value is negative, the controlled current output becomes negative correspondingly and the motor operates inversely.The current to which the unit voltage corresponds can be set in the drive.

PWM Command

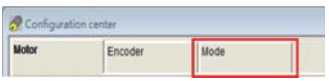
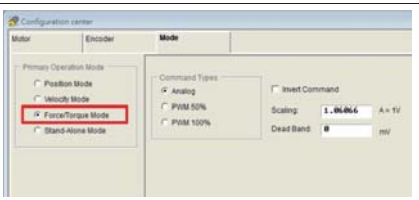
The PWM command is converted to a current command to directly control the current output and thus the force and torque of the motor. The current to which the Full PWM corresponds can be set in the drive.

4.6.3.1 Basic setting of force/torque mode

The basic setting of force/torque mode is described below.

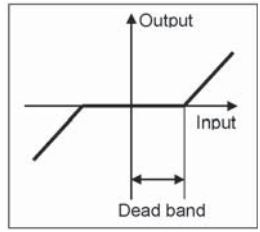
Step 1: Mode selection

The steps for selecting of force/torque mode via HMI are described below.

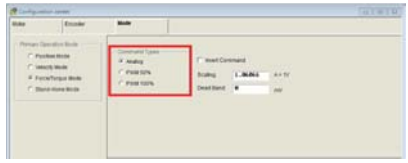
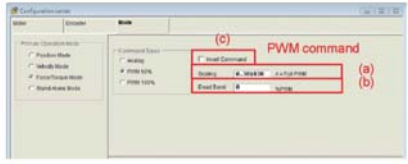
Step	Graphical (HMI) description	Operation
1		Execute the Lightening HMI program
2		Click the Configuration Center icon (as shown on the left) in the main function tool bar of the main HMI window, or select the Configuration Center option from 'Conf/Tune' in the function menu.
3		In the Configuration Center, select the 'Mode' tab, as show on the left figure
4		In the mode operation page, select "Force/Torque Mode", as show on the left figure.

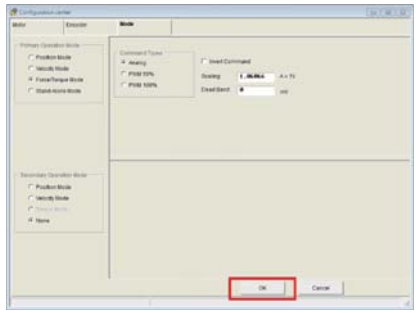
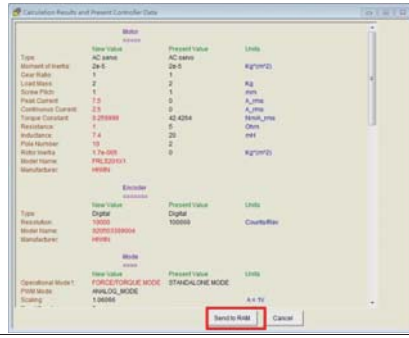
Step 2: Setting the command input format

The force mode is another application of the host controller that can send analog commands or PWM commands. Only the Scaling between the external command and current has to be set for the force/torque mode. The unit shows the corresponding relationship of 1 V with the amp or between the Full PWM and the highest amp value of the current. A dead band can be set for the current command. This will be zero when the input voltage or PWM is lower than this setting. Please refer to the figure below.



The steps for setting the command input format via HMI are described below.

Step	Graphical (HMI) description	Operation
1		In the mode operation page, key in the required command input format from the 'Command Types' (as shown on the left)
2		In the mode operation page, set the scaling between external command and current for requirement. The unit shows the corresponding relationship of 1V with the amp, or between the Full PWM and the highest amp value of the current as show (a) on the left figure.
3		Set the 'Dead Band' for the current command, as show (b) on the left figure.
4		Select "Invert Command" to invert voltage or PWM command for requirement, as show (c) on the left figure.

5		After finishing all the setting, click the “OK” button, as show on the left figure.
6		The parameter confirmation screen appear, click the “Send to RAM”, as show on the left figure.
7		Click the ‘Save to Flash’ button in the main function tool bar in the main HMI window to save the parameters in the flash memory. This will retain the parameters even if the drive is turned off.

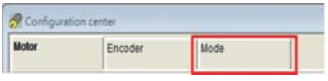
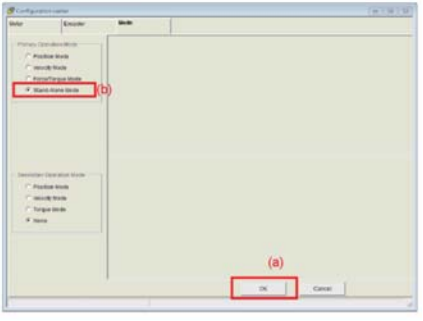
4.6.4 Stand-Alone mode

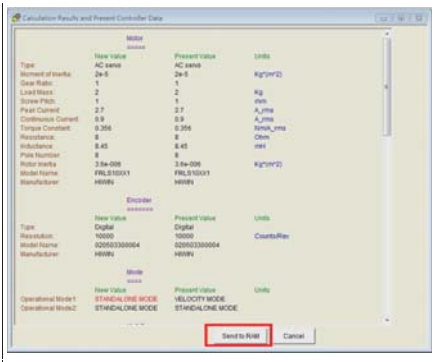
Stand-Alone mode is a mode for independent operation. The drive has a high-speed DSP that can perform motion planning by itself. With the support of the DSP, the drive can execute the internal motion program and drive the motor independently without using the external motion control card.

4.6.4.1 Basic setting of Stand-Alone mode

The basic setting of Stand-Alone mode is described below:

Step 1: Selection of the mode
The steps for setting Stand-Alone mode by via HMI are described below:

Step	Graphical (HMI) description	Operation
1		Execute the Lightening HMI program
2		Click the Configuration Center icon (as shown on the left) in the main function tool bar in the main HMI window, or select the Configuration Center option from 'Conf/Tune' in the function menu.
3		In the Configuration Center, select the 'Mode' tab (as shown on the left)
4		In the mode operation page, select 'Stand-Alone Mode' (a) on the left figure
5		After the settings are completed, click the 'OK' button (b) on the left

6		The parameter confirmation screen appears; Click “Send to RAM”, as shown on the left figure
7		Click the ‘Save to Flash’ button in the HMI main function tool bar to save the parameters in the flash memory. This will retain the parameters even if the drive is turned off.

4.7 Save to flash

Click the 'Save to Flash' button in the main HMI window to save the current parameters in the flash memory. Parameters saved in the flash memory will be retained even if the drive is turned off.

1. The emulated encoder output function will temporarily fail when the parameters are saved. If the host controller is connecting to the emulated encoder output signal, the encorder information that the host controller receives may be lost.
2. The compensation table of the error mapping function will not be saved. A save action must be executed on the 'Error Map' page to save the compensation table.

5 LCD

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5.1 LCD panel description

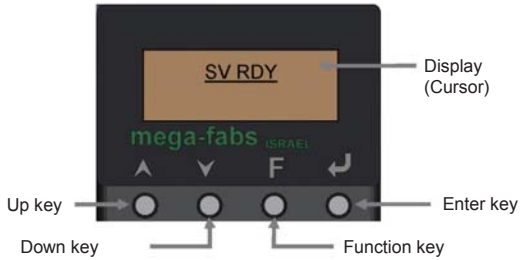


Fig. 5-1 LCD panel

Table 5-1

Name	Function
Display	For displaying changes in values, statuses, parameters and actions.
Up key	For the selection and setting of parameter values or jogging.
Down key	For the selection and setting of parameter values or jogging.
Function key	For switching among the four LCD page and switching the edit modes when setting parameter values.
Enter key	For entering the status display options, saving parameter settings and confirming input actions.
Cursor	Static cursor: A flashing underscore means that a parameter can be edited. Dynamic cursor: A solid flashing box means that parameters are being edited/motion is in progress (jogging). No cursor: Parameters can only be displayed, not edited.

※ Note: Pressing and holding the Up or Down keys enables users to quickly switch between pages.

5.2 Four LCD pages

There are four LCD pages on the display panel: Home Page, Display Parameters Page, Change Parameters Page and Actions Page. Press the Function key to switch between pages. The operation structure of the LCD is shown in Fig. 5-2.

Home Page
Displays the servo state, error messages, warnings and motor state (phase initialization, motor movement, homing and error mapping).

Display Parameters Page
Displays the motor feedback position, position command, position error, feedback velocity, velocity command, I/O state and other parameters.

Change Parameters Page
Allows changing the common gain (CG), velocity loop gain (VPG), phase initialization gain (ST_CG), operation mode and pulse format, save the parameters from RAM to the flash memory, and provide settings for 200 advanced parameters.

Actions Page
Allows the servo to perform enable, disable, jogging and moving to an absolute target position.

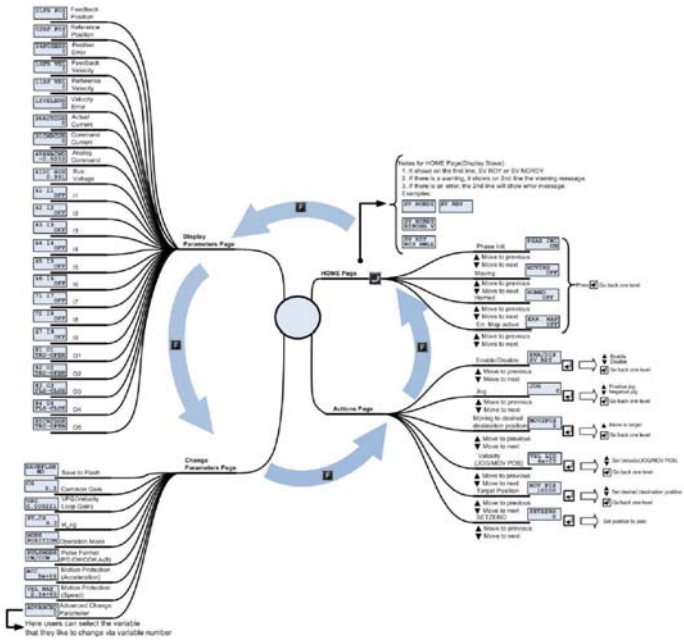

Display Parameters Page
HOME Page
Actions Page
Change Parameters Page
Here users can select the variable that they like to change via variable number

Fig. 5-2 LCD operation structure

5.2.1 Home Page

When the drive is powered on, the servo state of the drive is first displayed on the LCD. The servo state codes are described as follows.

Table 5-2

Code	Description
SV RDY	Servo is ready.
SV NORDY	Servo is not ready.

When the D2 drive detects errors, an error or warning message will appear on the second line as shown in Fig. 5-3. Definitions of these error and warning codes are shown in Table 5-3 and Table 5-4 respectively.

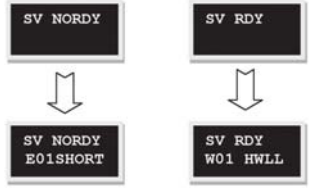


Fig. 5-3 Errors and warnings

Table 5-3 Description of error codes

No.	Code	Lightening error messages
1	E01SHORT	Motor short (over current) detected
2	E02OVERV	Over voltage detected
3	E03PEBIG	Position error too large
4	E04ENCOD	Encoder error
5	E05SWHOT	Soft-thermal threshold reached
6	E06UVWCN	Motor maybe disconnected
7	E07D.HOT	Amplifier over temperature
8	E08M.HOT	Motor over temperature sensor activated
9	E09UND.V	Under voltage detected
10	E10V5ERR	5V for encoder card fail
11	E11PHINI	Phase initialization error
12	E12SER.E	Serial encoder communication error
13	E13HAL.E	Hall sensor error
14	E14PHERR	Hall phase check error

Table 5-4 Description of warning codes

No.	Code	Lightening warnings
1	W01SWLL	Left SW limit
2	W02SWRL	Right SW limit
3	W03HWLL	Left HW limit
4	W04HWRL	Right HW limit
5	W05SVBIG	Servo voltage big
6	W06PE	Position error warning
7	W07VE	Velocity error warning
8	W08CUR.L	Current limited
9	W09ACC.L	Acceleration limited
10	W10VEL.L	Velocity limited
11	W11BOTH	Both HW limits are active
12	W12I2T	I2T warning

Press on the home page to enter the servo status display, then press the Up or Down key to change the status to be displayed. Please refer to Fig. 5-4 for an illustrated description of the procedure. For example, the phase initialization is not completed when PHAS INI shows OFF, or the initialization is completed when it shows ON.

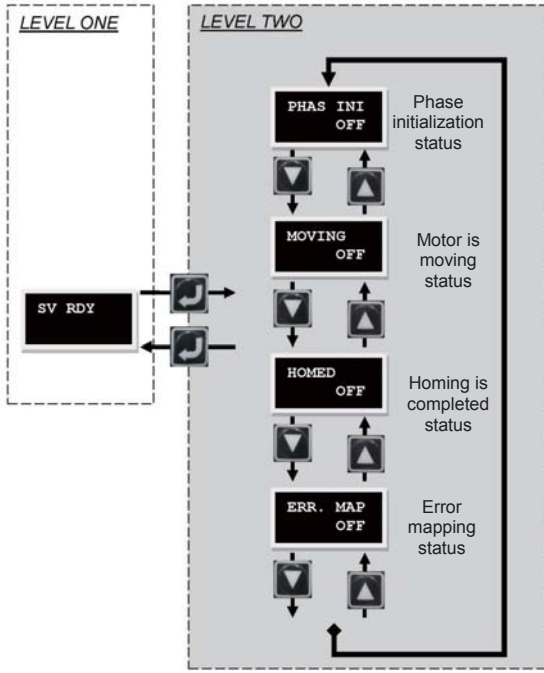


Fig. 5-4 Operation of the status display mode

5.2.2 Display Parameters Page

In the Display Parameters Page, press the Up or Down key to change the parameter to display. Please refer to Fig. 5-5 for an illustrated description of the procedure. The definition of each parameter display code is shown below. The name of the parameter is shown on the first line, and its value and status are show on the second line of the display.

Fig. 5-5 Operation of the parameter display mode

Fig. 5-6 Definition of parameter display codes

Code	Actual Value	Description	Unit
01FB POS	Feedback Position	Motor feedback position	count
02RF POS	Reference Position	Drive reference position	count
04POSERR	Position Error	Position error	count
10FB VEL	Feedback Velocity	Motor feedback velocity	count/s
11RF VEL	Reference Velocity	Drive reference velocity	count/s
12VELERR	Velocity Error	Velocity error	count/s
30ACTCUR	Actual Current	Motor Actual current	A_amp
31CMDCUR	Command Current	Drive Current command	A_amp
40ANACMD	Analog Command	Analog voltage command (from the host controller)	Volt
41DC BUS	Bus Voltage	Bus voltage	Volt
61 I1	I1	Input point 1	-
62 I2	I2	Input point 2	-
63 I3	I3	Input point 3	-
64 I4	I4	Input point 4	-
65 I5	I5	Input point 5	-
66 I6	I6	Input point 6	-
71 I7	I7	Input point 7	-
72 I8	I8	Input point 8	-
67 I9	I9	Input point 9	-
81 O1	O1	Output point 1	-
82 O2	O2	Output point 2	-
83 O3	O3	Output point 3	-
84 O4	O4	Output point 4	-
85 CN2BRK	CN2 BRK	Output point 5 (brake signal)	-

The status display of parameters O1-O4 is shown in Fig. 5-7 and the status codes are described in Table 5-5.

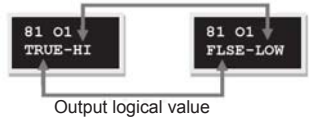


Fig. 5-7 Output status display

Table 5-5 Definition of output status codes

Code	Description
TRUE	True
FLSE	False
HI	High voltage
LOW	Low voltage

5.2.3 Change Parameters Page

Press the Up or Down key to switch the parameters to be changed in the change parameter page. Please refer to Fig. 5-8 for an illustrated description of the procedure. The detailed operating procedure is described in the next section.

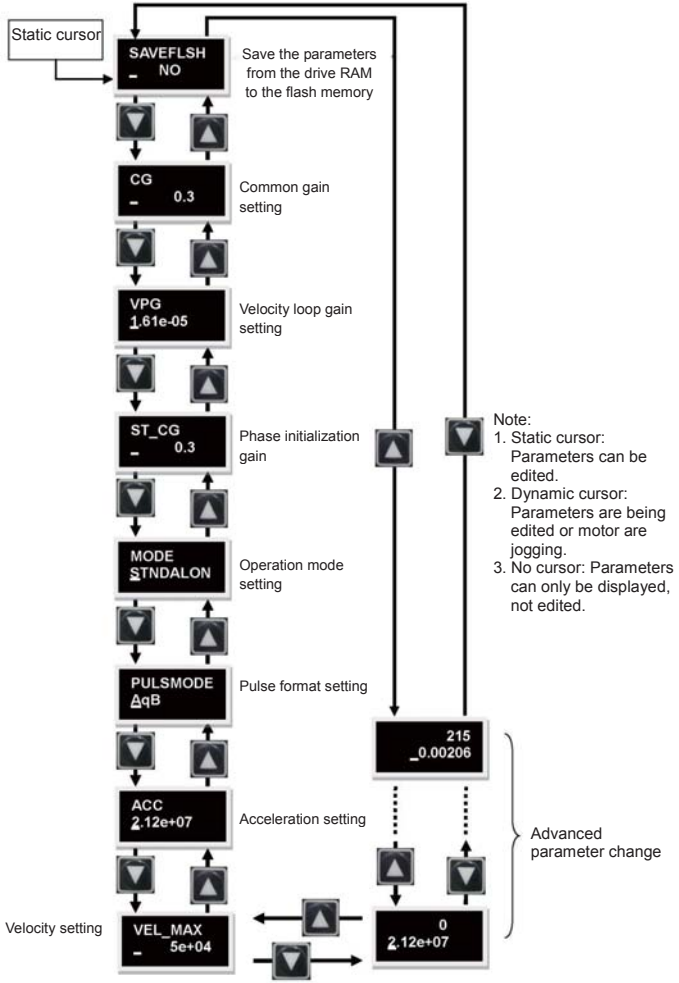


Fig. 5-8 Operation of the parameter change mode

5.2.3.1 Save to flash

The following operation shows the steps to save the parameters from the drive RAM to the flash memory (SAVE FLASH):

(1) Press the Enter key to enter the SAVE FLSH option. (A solid flashing cursor appears on the left side of the second line.)

(2) Press the Up or Down key (YES/NO) to select whether to save the parameters from the drive RAM to the flash memory. Select YES to continue.

(3) When the servo is disable (DISABLE), press the Enter key and the message 'PROCESS.' will appear on the screen, indicating that the parameters are being saved to the flash memory. The 'FINISH!' message will appear after completing the save. Please refer to Fig. 5-9 for an illustrated description of the procedure.

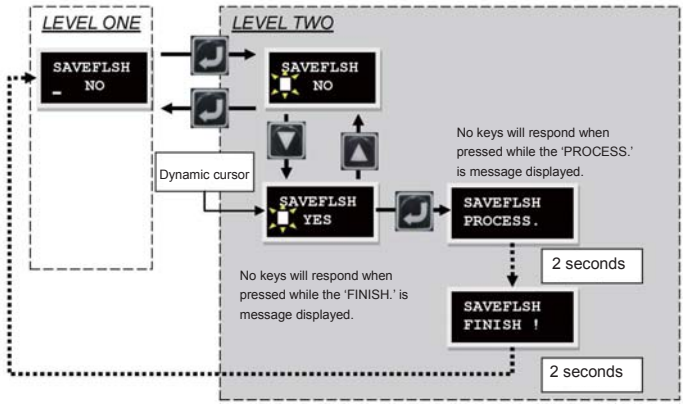


Fig. 5-9 Operation of 'Save to flash'

5.2.3.2 Parameter edit function

The editable parameters of the drive, such as CG/VPG/ST_CG/MODE/PULSMODE /ACC/VEL_MAX/advanced parameters, are variables which can be used to set values. The parameter edit function on the LCD can be used for setting values, or use the Up and Down keys to move the cursor or switch the values based on users's needs. Press the Function key to switch between functions. The following example is used to perform how to change the CG parameter, and the changes of all other parameters can be referred to this example. If the CG needs to be changed from 0.5 to 1.2, enter the CG editing page and follow the below setting procedure to change the parameters. Please refer to Fig. 5-10 for an illustrated description of the procedure:

(1) Press the Enter key to enter the CG edit mode. (A solid flashing cursor will appear on the left side of the second line.)
(2) Press the Down key and the flashing cursor will move to the "0" position.
(3) Press the Function key. (This allows the Up and Down keys to change parameter values.)
(4) Press the Up key twice and stop when the number turns to "1".
(5) Press the Function key. (This allows the Up and Down keys to move the cursor.)
(6) Press the Down key twice to move the flashing cursor to the "5" position.
(7) Press the Function key. (This allows the Up and Down keys to change parameter values.)
(8) Press the Down key three times and stop when the number turns to "2".
(9) Press the Enter key and the CG changes to 1.2.

Note: The following instructions are for the Function key when using the LCD parameter edit function:

(a) When pressing the Function key for less than one second, the operation function switches the Up and Down keys between moving the cursor and changing parameter values.
(b) When pressing and holding the Function key for more than two seconds, the screen will return to LEVEL ONE and any changes will be discarded.

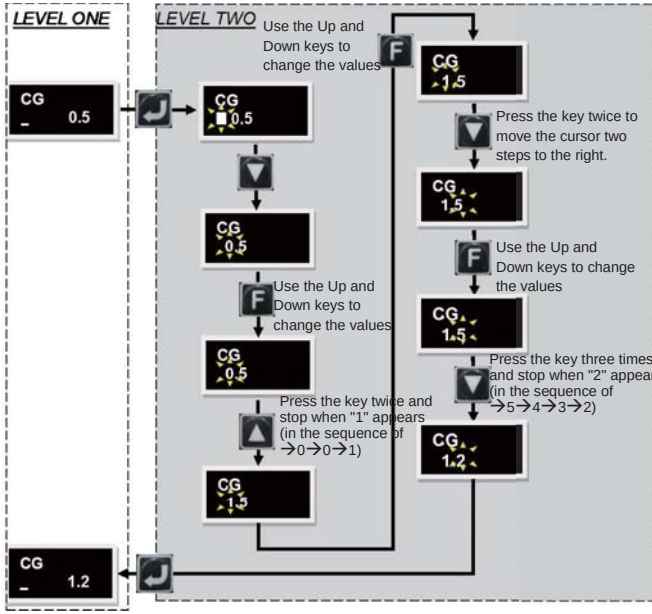

LEVEL ONE
LEVEL TWO
Use the Up and Down keys to change the values
Press the key twice to move the cursor two steps to the right.
Use the Up and Down keys to change the values
Use the Up and Down keys to change the values
Press the key three times and stop when "2" appears (in the sequence of →5→4→3→2)
Press the key twice and stop when "1" appears (in the sequence of →0→0→1)
CG 0.5
CG 1.2

Fig. 5-10 Operation of the CG parameter change (example)

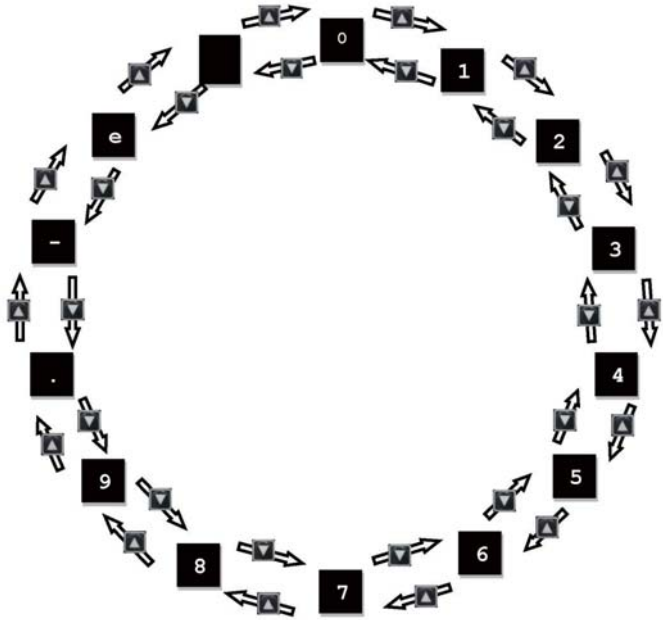


Fig. 5-11 Number switching sequence in parameter edit mode

5.2.3.3 Changes of non-numeric parameters

The drive operation mode and the pulse format of the host controller allow for changing non-numeric parameters.

Operation Mode

Follow the operation steps below to change the operation mode settings. Please refer to Fig. 5-12 for an illustrated description of the procedure.

(1) Press the Enter key to enter the non-numeric parameter change mode. (A solid flashing cursor appears on the left side of the second line).

(2) Press the Up or Down key to select the Position, Velocity, Force/Torque (Current) or Stand-Alone mode.

(3) Press the Enter key to confirm the setting change.

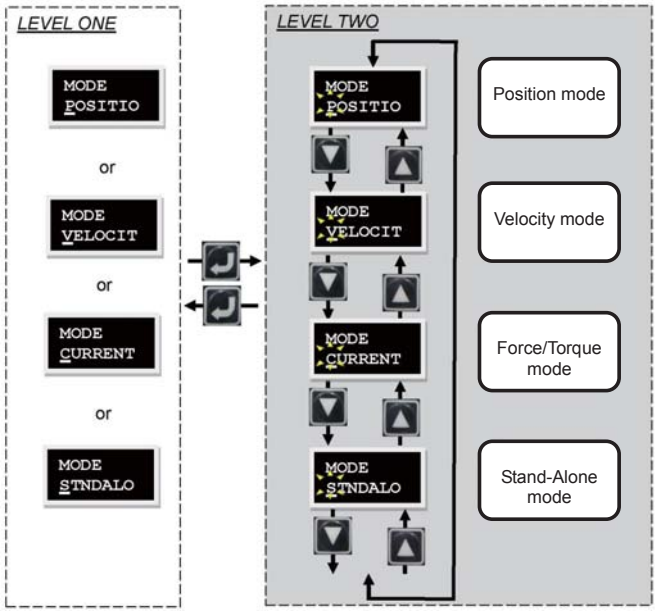


Fig. 5-12 Changing the operation modes

Pulse Format

Follow the operation steps below to change the pulse format settings. Please refer to Fig. 5-13 for an illustrated description of the procedure.

(1) Press the Enter key to enter the non-numeric parameter change mode. (A solid flashing cursor appears on the left side of the second line).

(2) Press the Up or Down keys to select the control input (Pulse and Direction, Pulse Up/Pulse Down, and Quadrature).

(3) Press the Enter key to confirm the setting change.

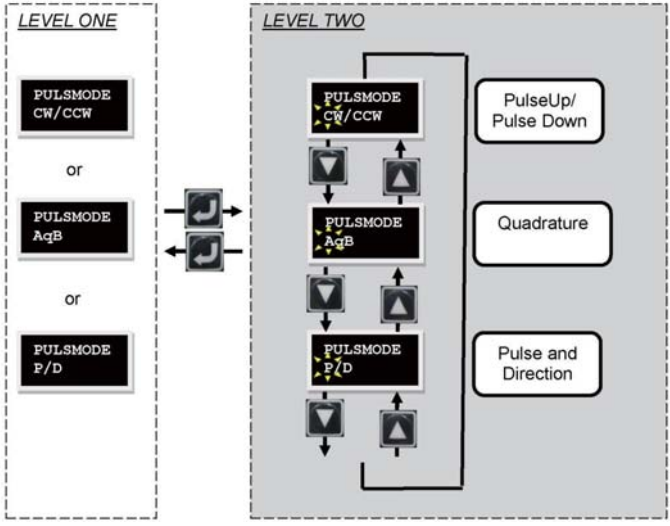


Fig. 5-13 Changing the pulse format

5.2.3.4 Setting advanced parameters

There are over 100 variables to change in LEVEL ONE. The variable codes are shown in Table 5-6.
(The * symbol means that the variable is also applicable to Drive with Pulse Only function.)

Table 5-6 Advanced parameters

LCD No	Parameter	Definition	Unit
0*	X_acc	Maximum acceleration of the motor output in motion	count/s^2
1*	X_dcc	Maximum deceleration of the motor output in motion	count/s^2
2*	X_dcc_kill	Deceleration of the motor output in an emergency stop	count/s^2
3*	X_vel_max	Maximum velocity of the motor in motion	count/s
4*	X_sw1_pos	Lower SW limit	count
5*	X_sw2_pos	Upper SW limit	count
6*	X_p2p_del	Point to Point (P2P) delay time	msec
7*	X_p2p_pos1	Point to Point (P2P) position 1	count
8*	X_p2p_pos2	Point to Point (P2P) position 2	count
16*	X_sof_fr	Frequency of phase initialized filter1 of SW method 1	Hz
17*	X_sof_xi	Damping ratio of phase initialized filter1 of SW method 1	-
18*	X_sof_k1	Parameter of phase initialized filter1 of SW method 1	-
19*	X_sof_k2	Parameter of phase initialized filter1 of SW method 1	-
20*	X_nf_fr	Frequency of phase initialized filter2 of SW method 1	Hz
21*	X_nf_xi	Damping ratio of phase initialized filter2 of SW method 1	-
22*	X_nf_k1	SW method 1 parameter of short excited filter 2	-
23*	X_nf_k2	Parameter of phase initialized filter2 of SW method 1	-
24*	X_f1_fr	Frequency of the closed-loop filter 1	Hz
25*	X_f1_xi	Damping ratio of the closed-loop filter 1	-
26*	X_f1_k1	Parameter of closed-loop filter 1	-
27*	X_f1_k2	Parameter of closed-loop filter 1	-
28*	X_f2_fr	Frequency of closed-loop filter 2	Hz
29*	X_f2_xi	Damping ratio of closed-loop filter 2	-
30*	X_f2_k1	Parameter of closed-loop filter 2	-
31*	X_f2_k2	Parameter of closed-loop filter 2	-
32*	X_Upi_kp	Current loop proportional gains (D axis)	-
33*	X_Upi_ki	Current loop integral gains (D axis)	-
35*	X_Vpi_kp	Current loop proportional gains (Q axis)	-
36*	X_Vpi_ki	Current loop integral gains (Q axis)	-
39*	X_index_vel	Slow homing velocity (slower speed)	count/s
40*	X_index_tout	Time out of homing process.	66.67US
42*	out_xor	Invert voltage for digital output	-
43*	X_cntperunit	Number of rotary motor counts in a revolution	-
44*	X_pitchScrew	Screw pitch	mm
45*	X_enc_360	Number of rotary motor counts in a revolution	count
46*	X_sm_ampl	Current for Phase initialization	(A_ampx 1000)/(curr_d rv_peak)
47*	X_enc_360_div	Motor pole-pair counts	-
48*	X_st_vpg	Velocity gains of SW method 1 in Phase initialization	-
49*	X_st_cg	Common gains of SW method 1 in Phase initialization	-
50*	X_max_err	Maximum position error	count
51*	X_curr_mot_peak	Motor peak current	A_amp

53*	X_curr_mot_cont	Motor continuous current	A_amp
59*	X_vpg	Closed-loop velocity proportional gains	-
64*	X_affg	Closed-loop acc feedforward gains	-
65*	X_CG	Common gains	-
66*	X_sg_run	Schedule gain in movement	-
67*	X_sg_idle	Schedule gain in In-position	-
68*	X_sg_stop	Schedule gain in settling	-
69*	X_Ucf_fr,	Frequency of current loop filter (D axis)	Hz
70*	X_Ucf_xi	Damping ratio of current loop filter (D axis)	-
71*	X_Vcf_fr	Frequency of current loop filter (Q axis)	Hz
72*	X_Vcf_xi	Damping ratio of current loop filter (Q axis)	-
74*	X_tr_time	In-position debounce time	66.67US
75*	X_tr	In-position error target radius	count
76*	X_forceConstant	Torque constant	Nm /A_amp
78*	X_mInert	Rotational inertia of rotary motor	Kg* (m^2)
79*	X_gearRatyio	Reduction gear ratio	-
80	Vcmd_offs	Analog input	Volt
81*	X_cmd_ext_N	Numerator of the electronic gear ratio (output)	-
82*	X_cmd_ext_M	Denominator of the electronic gear ratio (input)	-
83	X_cmd_ext_v_sc	Velocity command ratio, indicating the rotational speed of 1V	count/s=1 V
84	X_cmd_ext_v_dz	Dead band for the velocity command; the velocity command is 0 when the input voltage is lower than this setting	Volt
85	X_cmd_ext_i_sc	Current command ratio, indicating the rotational speed of 1V	(Aampx1000) /(curr_drv_peak) =1V
86	X_cmd_ext_i_dz	Dead band for the current command; the velocity command is 0 when the input voltage is lower than this setting	Volt
88*	X_pos_err_warn_win	Position error warning	count
89*	X_vel_err_warn_win	Velocity error warning	count/s
90*	X_Resistance	Motor line-line resistance	ohm
91*	X_Inductance	Motor line-line inductance	mH
92*	X_ vel_stop	Brake starting speed	count/s
93*	X_delMaxEnToBrk	Brake starting delay time	66.67US
94*	X_delBrkToDis	The brake active time	66.67US
95*	X_index_offs	Home offset	count
112*	X_Aenc_sgn	Encoder direction	-
113*	X_Aenc_mode	Encoder type	-
115*	X_new_sm_fac	Smooth factor	-
116*	in_xor	Logic inversion setting for digital input	-
124*	pullupdn	Digital input signal level setting	-
125*	X_rotaryType	Motor type	-
126*	X_st_phase	Motor inverse output force	-
129*	X_pulse_mode	Pulse format	-
130*	X_pulse_dir	Inverse pulse command	-
131*	X_fall_rise	Pulse command trigger	-
132	X_cmd_pwm_mode	Command input format in the velocity and current modes	-

133*	out_config[0]	O4 output signal setting	-
134*	out_config[1]		-
135*	out_config[2]		-
136*	out_config[3]		-
137*	out_config[4]	O1 output signal setting	-
138*	out_config[5]		-
139*	out_config[6]		-
140*	out_config[7]		-
141*	out_config[8]	O2 output signal setting	-
142*	out_config[9]		-
143*	out_config[10]		-
144*	out_config[11]		-
145*	out_config[12]	O3 output signal setting	-
146*	out_config[13]		-
147*	out_config[14]		-
148*	out_config[15]		-
149*	X_StIdenext	Hardware enable signal setting (Axis Enable)	-
150*	X_StIdRL	Hardware right limit signal setting (Right Limit Switch)	-
151*	X_StIdLL	Hardware left limit signal setting (Left Limit Switch)	-
153*	X_StIdhome	The homing okay command from the host controller (Homing OK, Start Error Map)	-
154*	X_StIdOutBrake	Brake signal setting	-
155*	X_sw_pos_prot_en	On/Off SW limit	-
156*	X_hw_lim_prot_en	On/Off limit switch	-
157*	X_emu_N	Numerator of emulated encoder output	-
158*	X_emu_M	Denominator of emulated encoder output	-
159*	X_emap_en	On/Off error mapping	-
160*	X_StIdReset	Drive reset signal setting (Reset Amplifier)	-
162*	X_home_smoot h	Homing smooth factor	-
163*	ver_mdp	Firmware version	-
164*	X_emu_i_radius	Emulated encoder home radius	count
165*	X_emu_i_jitter	Emulated encoder filter factor	count
166*	X_dcbl_pulse_mode	Phase initialization mode	-
167*	X_dcbl_pulse_amp	SW method 5 phase initialization current	(Aampx1000) /(curr_drv_peak)
168*	X_dcbl_pulse_del	SW method 5 phase initialization time factor	66.67us
172*	X_vsf.fr	VSF frequency	Hz
173*	X_vsf.xi	VSF damping factor	-
174*	X_vsf_en	VSF switch	-
175*	X_cmd_ext_N2	Numerator of the electronic gear ratio (second output set)	-
176*	X_cmd_ext_N3	Numerator of the electronic gear ratio (third output set)	-
177*	X_cmd_ext_N4	Numerator of the electronic gear ratio (fourth output set)	-
178*	X_fric_comp_up	Friction compensation	0.1%*curr_drv_peak (A_amp)
179*	X_home_vel	Fast homing velocity (Faster Speed)	count/s
180*	X_home_option	Homing mode	-
181*	X_home_DIR	Homing start direction	-

182*	X_home_opt0_index	Homing mode 1 index searching setting	-
183*	X_home_left_SW	Left condition for homing	-
184*	X_home_right_SW	Right condition for homing	-
185*	X_home_wall_CurrThrshld	Current threshold of hitting the hard stop	(Aampx1000)/(curr_drv_peak)
186*	X_home_wall_CurrTime	Duration time of hitting the hard stop	msec
187*	X_home_select_Speed	Homing mode 2 initial speed selection	count/s
188*	X_home_search_option	Search homing method option 2	-
189*	X_backlash	Backlash	count
191*	X_StIdNearHome	Near home sensor.	-
192*	X_StIdClrErr	Clear errors	-
193*	X_StIdInvCmd	Invert command	-
194*	X_StId2ndCG	Switch to secondary CG	-
195*	X_StId2ndVPG	Switch to secondary VPG gains	-
196*	X_StIdZSC	Zero speed clamp	-
197*	X_StIdINH	Inhibit pulse command	-
198*	X_StIdPS	Switch HI/LO pulse input	-
199*	X_StIdAbort	Abort motion	-
200*	X_StIdClrPE	Clear position error	-
201*	X_StId2ndOperode	Switch to secondary mode	-
202*	X_StIdStartHome	Start the built-in homing procedure of the drive (Start Homing)	-
203*	X_StIdDiv1	Electronic gear select DIV1	-
204*	X_StIdDiv2	Electronic gear select DIV2	-
205*	out_config [16]	CN2BRK brake output signal setting	-
206*	out_config [17]		-
207*	out_config [18]		-
208*	out_config [19]		-
211*	X_vffg	Velocity feedforward	-
212*	X_oper_mode1	Primary operation mode	-
213*	X_oper_mode2	Secondary operation mode	-
214*	X_second_cg	Secondary CG	-
215*	X_second_vpg	Secondary VPG	-

5.2.4 Actions Page

In the action mode, users can perform enable/disable, JOG and absolute coordination motion, and SETZERO functions. The velocity and target coordinates for motions can also be set, or press the Up or Down key to switch the actions to be performed. Please refer to Fig. 5-14 for an illustrated description of the procedure. The detailed operating procedure is described in the next section.

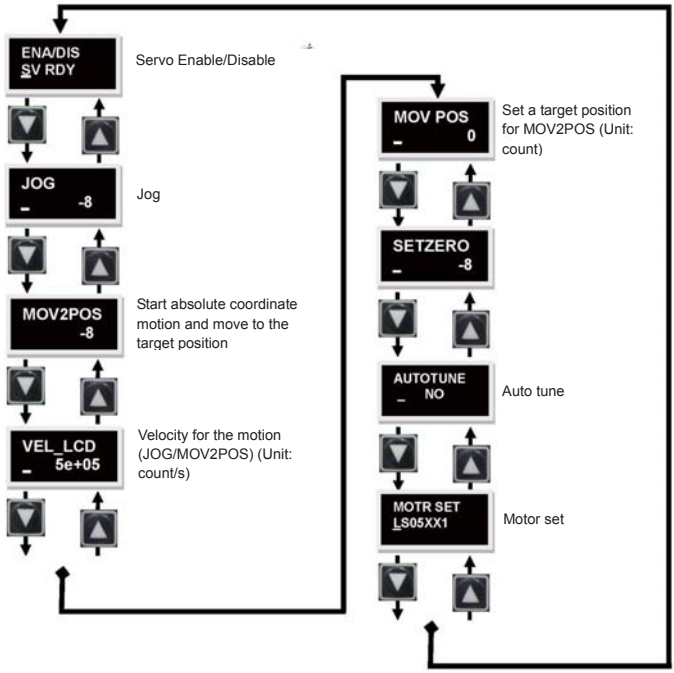


Fig. 5-14 Operation modes example

5.2.4.1 Motor Set

The following example shows the actions necessary to select the model number of the motor and perform the three initialization steps on the LCD to drive the motor. Please refer to the following description for the procedure. A motor with model number FRMS402XX1, operating in the Stand-Alone mode, is used as an example below.

(1) Press the Enter key to enter the MOTR SET setting, then press the Up or Down key to select a model number (MS402XX1) to which the drive is to be connected. Press the Enter key to confirm the selection.
(2) The LCD screen automatically moves to the AUTOTUNE page. Press the Enter key to enter the AUTOTUNE setting screen. Users can only select YES on this page. Press the Enter key to confirm the auto tune. If the auto tune is performed successfully, continue to Step 3. Please refer to 5.2.4.2 for a detailed description of the procedure.
(3) The LCD screen next automatically moves to the MODE page. Press the Enter key to enter the MODE setting screen, press the Up or Down key to select STNDALON, then press the Enter key to confirm the selection.
(4) The LCD screen now automatically moves to the SAVE TO FLASH (SAVE FLSH) screen. Press the Enter key to enter the SAVE FLSH setting screen, then press the Up or Down key to select No. Press the Enter key to confirm that no parameters will be saved to the flash memory. Please refer to 5.2.3.1 for a detailed description of the procedure.
(5) The LCD screen finally automatically moves to the PHAS INI page in LEVEL TWO of the Home Page. Successful phase initialization is confirmed when ON is displayed on the screen.

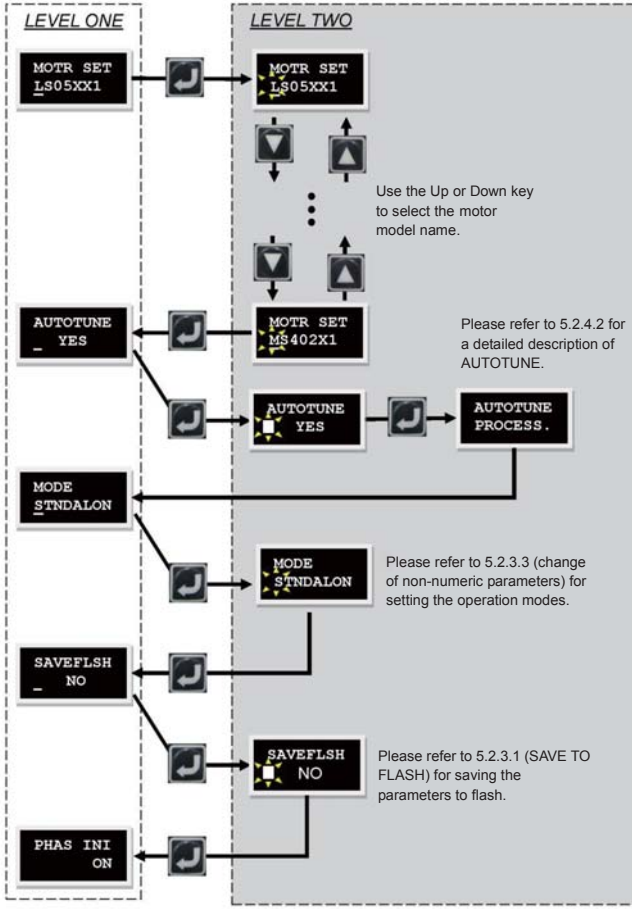

LEVEL ONE
LEVEL TWO
MOTR SET LS05XX1
MOTR SET LS05XX1
Use the Up or Down key to select the motor model name.
AUTOTUNE YES
MOTR SET MS402X1
Please refer to 5.2.4.2 for a detailed description of AUTOTUNE.
AUTOTUNE YES
AUTOTUNE PROCESS.
MODE STNDALON
MODE STNDALON
Please refer to 5.2.3.3 (change of non-numeric parameters) for setting the operation modes.
SAVEFLSH NO
SAVEFLSH NO
Please refer to 5.2.3.1 (SAVE TO FLASH) for saving the parameters to flash.
PHAS INI ON

Fig. 5-15 Operation of MOTR SET

5.2.4.2 AUTOTUNE

The following operation shows the steps to select whether to execute the AUTOTUNE setting. Please refer to Fig. 5-16 for an illustrated description of the procedure.

(1) Press the Enter key to enter the AUTOTUNE option. (A solid flashing cursor appears on the left side of the second line.)
(2) Press the Up or Down key to select whether to execute AUTOTUNE.
(3) The drive will execute AUTOTUNE when AUTOTUNE YES is selected and the Enter key pressed (AUTOTUNE do not be executed if AUTOTUNE NO is selected).

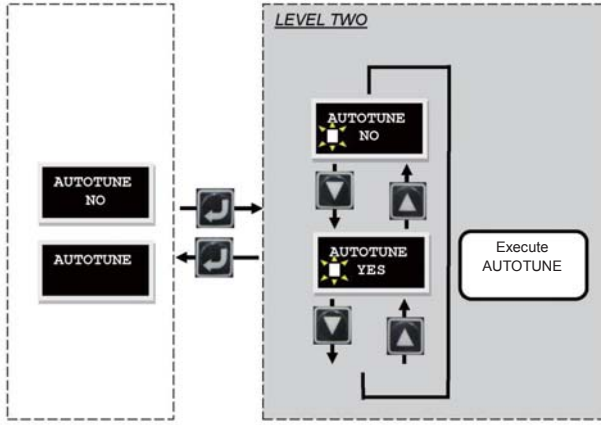


Fig. 5-16 Operation of AUTOTUNE

5.2.4.3 ENA/DIS

The following operation shows the ENA/DIS setting steps. Please refer to Fig. 5-17 for an illustrated description of the procedure.

(1) Press the Enter key to enter the ENA/DIS setting. (A solid flashing cursor appears on the left side of the second line.)
(2) Use the Up or Down key to select ENABLE or DISABLE.
(3) Press the Enter key after selecting to finish the setting.

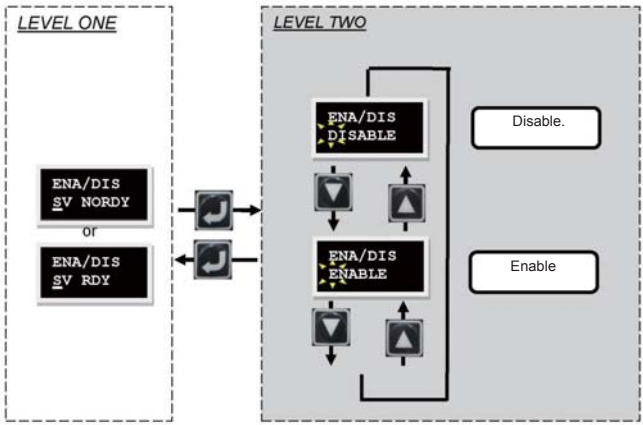


Fig. 5-17 Operation of excitation/de-excitation (ENA/DIS)

5.2.4.4 JOG

The following operation shows the JOG setting procedure. Please refer to Fig. 5-18 for an illustrated description of the procedure.

(1) Press the Enter key to enter the JOG mode. (A solid flashing cursor appears on the left side of the second line.)
(2) Use the Up or Down key to allow the motor to rotate normally or inversely (motion). The feedback position will display on the LCD when the motor is in motion. The motor stops immediately when the key is released.

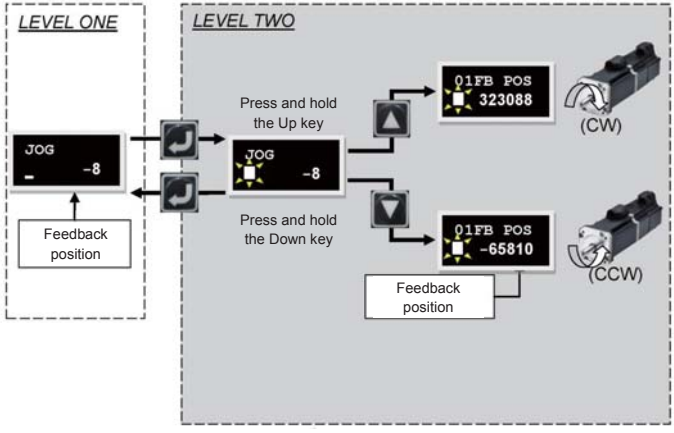


Fig. 5-18 Continuous motion (jog) operation

5.2.4.5 MOV2POS

The following operation shows the setting procedure for movement to an absolute coordinate position. Please refer to Fig. 5-19 for an illustrated description of the procedure. An absolute coordinate position of destination, 2000, is used as an example below.

(1) Use the Up or Down key to enter the MOV POS setting page. Please refer to the parameter edit function in 5.2.3.2 for the input method. In this example, the coordinate position of destination will be set to 2,000.
(2) Move to the MOV2POS option and press the Enter key. (A solid flashing cursor appears on the left side of the second line.) The current position is displayed, but the motion has not yet started.
(3) Press the Up key to start the motion. The motor moves to the destination (MOV POS) at the speed as set in VEL_LCD. The feedback position (01FBPOS) information is displayed on the second line on the LCD during the movement. To stop the motion during movement, simply press the Enter key to stop the motor. To resume the motion, press the Up key and the motor will move to the preset destination.
(4) Press the Enter key to return to LEVEL ONE.

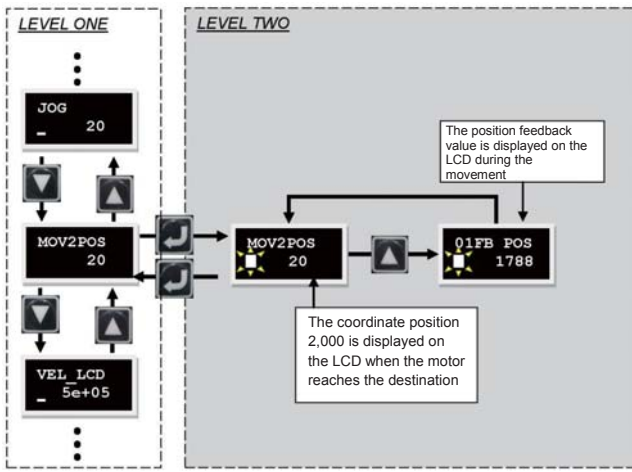


Fig. 5-19 Absolute coordinate motion (MOV2POS) operation

5.2.4.6 SETZERO

The following operation shows the steps for setting the current position to zero. Please refer to Fig. 5-20 for an illustrated description of the procedure.

Press the Up or Down key to enter the SETZERO setting. Press the Enter key to set the current position to zero.

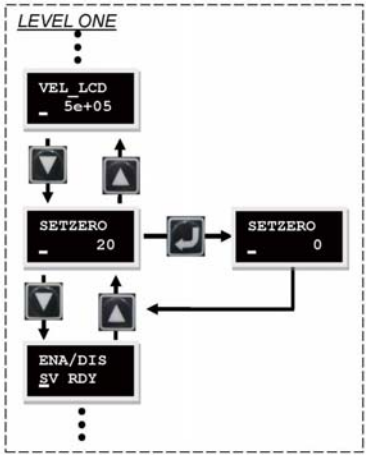


Fig. 5-20 Operation of set to zero (SETZERO)

5.3 LCD configuration by mode

5.3.1 Position mode

The host controller sends a pulse to the drive. This pulse is the same as position command and the drive moves a corresponding distance each time it receives a pulse. The host controller is responsible for trajectory planning. The pulse is sent more quickly when the host controller is on acceleration motion, and is sent at a fixed frequency when the host controller transmits the signal at a constant speed motion.

5.3.1.1 Basic setting of position mode

The basic setting of position mode is described below.

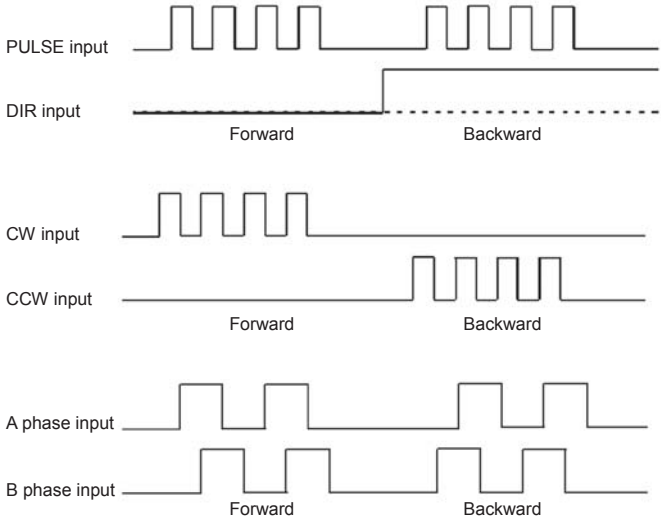
Step 1: Mode selection

The steps for selecting position mode on the LCD are described below.

Step	LCD display after operation	Keys to be used	Operation
1			When the drive is powered on, the enable state of the drive is first displayed on the LCD.
2			Press the Function key twice to move to the parameter change mode.
3			Press the Down key three times to move to the operation mode setting screen.
4			Press the Enter key to enter the setting state.
5			Press the Down key to select the option for position mode.
6			Press the Enter key to confirm the setting.

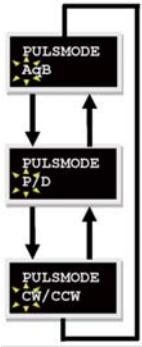
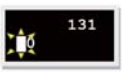
Step 2: Pulse format selection

The pulse is generated in three formats: PulseE/Dir, Pulse Up/Pulse Down or CW/CCW, and AqB phase (Quadrature) square wave as shown in the figure below.



The steps selecting the pulse format on the LCD are described below.

Step	LCD display after operation	Keys to be used	Operation
1	MODE POSITION	▲ ▼ F ↵	Use the last setting screen from Step 1 above.
2	PULSMODE AqB	▲ ▼ F ↵	Press the Down key once to move to the pulse format setting screen.
3	PULSMODE AqB	▲ ▼ F ↵	Press the Enter key to enter the setting screen.

4			Press the Up or Down key to select the required pulse format for the Control Input.
5			Press the Enter key to finish the pulse setting.
6			Press and hold the Down key to move to Page with LCD No. 131. This is the page for selecting the pulse command trigger. (Please refer to Note 1 for more information about the LCD number 131).
7			Press the Enter key to select the required pulse command trigger (in this example, the trigger is set to Rising Edge).
8			Press the Down key to move the cursor one step to the right.
9			Press the Function key and then press the Up key to set the parameter to 1. The pulse command trigger has now been set to Rising Edge.
10			Press the Enter key to finish setting the pulse command trigger.

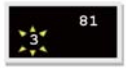
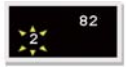
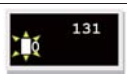
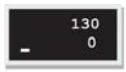
Note 1: The pulse command trigger is set using the following parameters.

LCD no.	Parameter	Definition	Initial value
131	X_fall_rise	Pulse command trigger *(0: Falling Edge/1: Rising Edge)	0

Step 2: Electronic gear setting

The electronic gear can be set in Pulse Mode. One input pulse normally corresponds to one encoder count. A gear ratio of 2:3, for example, means two input pulses correspond to three encoder counts. A total of four sets of electronic gear ratios can be set. They can be switched using two I/Os (DIV1 and DIV2).

The steps for setting the electronic gear ratio on the LCD are described below.

Step	LCD display after operation	Keys to be used	Operation
1			Use the last setting screen from Step 2 above.
2			Press and hold the Up key to move to Page with LCD No. 81. This is the page for selecting the numerator (output) of the electronic gear ratio. (Please refer to Note 2 for more information about the LCD number 81).
3			Press the Enter key and change the parameter from 1 to 3. Please refer to the parameter edit function in 5.2.3.2 for the parameter change method (in this example, a gear ratio of 2:3 is used).
4			Press the Enter key to finish setting the encoder count.
5			Press the Down key to move to Page with LCD No. 82. This is the page for selecting the denominator (input) of the electronic gear ratio. (Please refer to Note 2 for more information about LCD number 82).
6			Press the Enter key and change the parameter from 1 to 2. Please refer to the parameter edit function in 5.2.3.2 for the parameter change method.
7			Press the Enter key to finish setting the input pulse.
8			Press and hold the Down key to move to Page with LCD No. 130. This is the page for selecting the inverse pulse command. (Please refer to Note 2 for more information about LCD number 130).
9			Press the Enter key to select the inverse pulse command (in this example, no inverse pulse command is selected).
10			Press the Enter key to finish the setting.

12			Press and hold the Up key to move to Page 124 on the LCD. This is the page for selecting the high/low speed pulse input. (Please refer to Note 2 for more information about LCD number 124).
12			Press the Enter key and change the parameter from 512 to 0. Please refer to the parameter edit function in 5.2.3.2 for the parameter change method (in this example, the high-speed pulse input is set).
13			Press the Enter key to finish the setting.
14			Press and hold the Up key to move to the SAVE FLSH page. Here the parameters can be saved to the flash. This will retain the parameters even if the drive is turned off.
15			Press the Enter key to enter the setting state.
16			Press the Up key to select YES.
17			Press the Enter key to save the parameters to the flash.

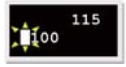
Note 2: The electronic gear and inverse pulse commands are set using the following parameters.

LCD no.	Parameter	Definition	Initial value
81	Xcmd_ext_N	Numerator of the electronic gear ratio (output)	1
82	Xcmd_ext_M	Denominator of the electronic gear ratio (input)	1
130	X_pulse_dir	Inverse pulse command	0
124	pullupdn	High/low speed pulse input (0: high-speed pulse input / 2048: low-speed pulse input)	512

Step 3: Smooth factor

Rapid increasing or decreasing the acceleration in a short time means that the force for an object can suddenly increase or decrease. Application of the smooth motion technique to the motion control loop is helpful for enhancing the performance and reducing such impacts. The D2 drive uses a smooth factor to determine the S-curve or T-curve track and the adjustment range is 0-500. The track is closer to an S-curve with a higher adjustment value, and is closer to a T-curve with a lower adjustment value. A value of 1 means no smooth function is enabled. When a higher smooth factor is used, in some cases the reduced output force of the motor is helpful for the final setting time during the positioning process. However, the move time will unavoidably increase when the motion becomes smoother. Henceforth, tests on the machine are needed to adjust the smooth factor and reach a balance. The motion protection function can be disabled when the smooth factor is set to 0.

The steps for setting the smooth factor on the LCD are described below.

Step	LCD display after operation	Keys to be used	Operation
1			Use the last setting screen from Step 3 above.
2			Press and hold the Down key to move to Page with LCD No. 115. This is the page for setting the smooth factor. (Please refer to Note 3 for more information about LCD number 115).
3			Press the Enter key and set the required smooth factor. Please refer to the parameter edit function in 5.2.3.2 for the setting method.
4			Press the Enter key to finish the setting.

Note 3: The smooth factor is set using the following parameters.

LCD no.	Parameter	Definition	Initial value
115	X_new_sm_fac	Smooth factor	100

5.3.2 Velocity Mode

The drive can receive commands from the host controller by voltage (V commands). The input voltage ranges from +10V to -10V. The drive converts the received +10V to -10V input voltage to the corresponding velocity control to drive the motor. In addition to the voltage, the host controller can send commands by PWM signals (PWM commands).The PWM command converts to different velocity commands depending on the duty cycle. It is classified into single-wire type (PWM-50%) and two-wire (PWM-100%) type. The single-wire type (PWM-50%) type refers to the duty cycle of 50%. An inverse motion occurs when the duty cycle is less than 50%, while normal motion occurs when the duty cycle is more than 50%. The two-wire type (PWM-100%) type needs one more pin to control the operation direction of the motor.

V Command
The analog voltage signal is converted to a velocity command, such that the drive can control the motor velocity. The higher the voltage value, the higher the output speed (but it will not exceed the maximum limit set by the drive). Conversely, the lower the voltage value, the lower the output speed. When the voltage value is negative, the output speed becomes negative too and the motor operates inversely. The command speed corresponds to how many unit voltage can be set in the drive.

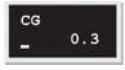
PWM Command
The PWM command is converted to a velocity command to directly control the operation speed of the motor. The velocity corresponds to how many Full PWM can be set in the drive.

4.3.2.1 Basic setting of velocity mode

The basic setting of velocity mode is described below.

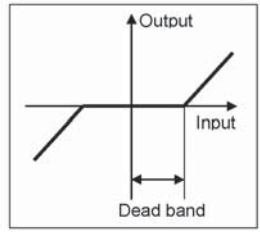
Step 1: Mode selection

The steps for selecting velocity mode on the LCD are described below.

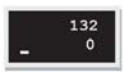
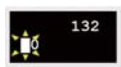
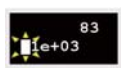
Step	LCD display after operation	Keys to be used	Operation
1			When the drive is powered on, the enable state of the drive is first displayed on the LCD.
2			Press the Function key twice to move to the parameter change mode.
3			Press the Down key three times to move to the operation mode setting screen.
4			Press the Enter key to enter the setting state.
5			Press the Down key to select the option for velocity mode.
6			Press the Enter key to confirm the setting.

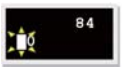
Step 2: Setting the command input format

Velocity mode can be used if the host controller can output analog commands or PWM commands. Only the ratio (scaling) between the analog commands and the velocity needs to be set for velocity mode. The unit shows the corresponding relationship of 1 V with mm/s or between the Full PWM and the maximum speed. The dead band can be set for the velocity command. The velocity will be 0 when the input voltage or PWM is lower than this setting. Please refer to the figure below.



The steps for setting the command input format on the LCD are described below.

Step	LCD display after operation	Keys to be used	Operation
1			Use the last setting screen from Step 1 above.
2			Press and hold the Down key to move to Page with LCD No. 132. This is the page for selecting the command input format in the velocity and current modes. (Please refer to Note 1 for more information about LCD number 132).
3			Press the Enter key and set the required command input format. Please refer to the parameter edit function in 5.2.3.2 for the setting method.
4			Press the Enter key to finish setting the command input format.
5			Press and hold the Up key to move to Page with LCD No. 83. This is the page for selecting the velocity command ratio. (Please refer to Note 1 for more information about LCD number 83).
6			Press the Enter key and set the required velocity command ratio. Please refer to the parameter edit function in 5.2.3.2 for the setting method. (To set an inverse voltage or PWM command, add a minus sign to the velocity command ratio).

7			Press the Enter key to finish setting the velocity command ratio.
8			Press the Down key to move o Page with LCD No. 84. This is the page for selecting the dead band for the velocity command. (Please refer to Note 1 for more information about LCD number 84).
9			Press the Enter key and set the required dead band. Please refer to the parameter edit function in 5.2.3.2 for the setting method.
10			Press the Enter key to finish setting the dead band.
11			Press and hold the Up key to move to the SAVE FLSH page. Here the parameters can be saved to the flash. This will retain the parameters even if the drive is turned off.
12			Press the Enter key to enter the setting state.
13			Press the Up key to select YES.
14			Press the Enter key to save the parameters to the flash.

Note 1: The settings are performed using the following parameters.

LCD no.	Parameter	Definition	Initial value
132	X_cmd_pwm_mode	The command input format in the velocity and current modes. (0: Analog / 1: PWM 50% / 2: PWM 100%)	0
83	X_cmd_ext_v_sc	The velocity command ratio, indicating the corresponding relationship of 1V with count/s, or between the Full PWM and the highest speed. (Unit: count/s=1V or count/s=Full PWM)	1000
84	X_cmd_ext_v_dz	Dead band for the velocity command; the velocity command is 0 when the input voltage is lower than the setting. (Unit: Volt)	0

5.3.3 Force/torque mode

The drive can receive commands from the host controller by voltage (V commands). The input voltage ranges from +10V to -10V. The drive makes the received +10V to -10V input voltage correspond to the current control to drive the motor. In addition to the voltage, the host controller can send commands by PWM signals (PWM commands).The PWM command converts to different velocity current commands depending on the duty cycle. It is classified into single-wire (PWM-50%) and two-wire (PWM-100%) types. The single-wire (PWM-50%) type refers to the duty cycle of 50%. An inverse motion occurs when the duty cycle is less than 50%, while normal motion occurs when the duty cycle is more than 50%. The two-wire (PWM-100%) type needs one more pin to control the operation direction of the motor.

V command
The analog voltage signal is converted to a current command to directly control the current output of the drive and thus the force and torque of the motor. The higher the voltage value, the higher the output current(but it will not exceed the maximum limit set by the drive). Conversely, the lower the voltage value, the lower the output current. When the voltage value is negative, the output current becomes negative too and the motor operates inversely. The current correspond to how many unit voltage can be set in the drive.

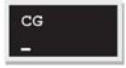
PWM Command
The PWM command is converted to a current command to directly control the current output and thus the force and torque of the motor. The current to which the Full PWM corresponds can be set in the drive.

5.3.3.1 Basic setting of force/torque mode

The basic setting of force/torque mode is described below.

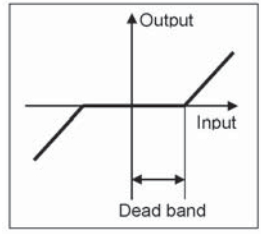
Step 1: Mode selection

The steps for selecting the force/torque mode on the LCD are described below.

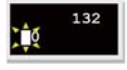
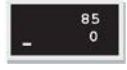
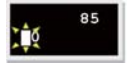
Step	LCD display after operation	Keys to be used	Operation
1			When the drive is powered on, the enable state of the drive is first displayed on the LCD.
2			Press the Function key twice to move to the parameter change mode.
3			Press the Down key three times to move to the operation mode setting screen.
4			Press the Enter key to enter the setting state.
5			Press the Down key three times to select the option for force/torque mode.
6			Press the Enter key to confirm the setting.

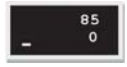
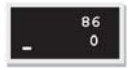
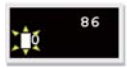
Step 2: Setting the command input format

The force mode is another application of the host controller that can output analog commands or PWM commands. Only the ratio (scaling) between the analog command and current for the force/torque mode. The unit shows the corresponding relationship of 1 V with the amp or between the Full PWM and the maximum amp value of the current. A dead band can be set for the current command. The current output will be 0 when the highest amp value of the current. A dead band can be set for the current command. This will be 0 when the input voltage or PWM is lower than this setting. Please refer to the figure below.



The steps for setting the command input format on the LCD are described below.

Step	LCD display after operation	Keys to be used	Operation
1			Use the last setting screen from Step 1 above.
2			Press and hold the Down key to move to Page with LCD No. 132. This is the page for selecting the command input format in the velocity and current modes. (Please refer to Note 1 for more information about LCD number 132).
3			Press the Enter key and set the required command input format. Please refer to the parameter edit function in 5.2.3.2 for the setting method.
4			Press the Enter key to finish setting the command input format.
5			Press and hold the Up key to move to Page with LCD No. 85. This is the page for selecting the current command ratio. (Please refer to Note 1 for more information about LCD number 85).
6			Press the Enter key and set the required current command ratio. Please refer to the parameter edit function in 5.2.3.2 for the setting method.

			(To set an inverse voltage or PWM command, add a minus sign to the current command ratio).
7			Press the Enter key to finish setting the current command ratio.
8			Press the Down key to move to Page with LCD No. 86. This is the page for selecting the dead band for the current command. (Please refer to Note 1 for more information about LCD number 86).
9			Press the Enter key and set the required dead band. Please refer to the parameter edit function in 5.2.3.2 for the setting method.
10			Press the Enter key to finish setting the dead band.
11			Press and hold the Up key to move to the SAVE FLSH page. Here the parameters can be saved to the flash. This will retain the parameters even if the drive is turned off.
12			Press the Enter key to enter the setting state.
13			Press the Up key to select YES.
14			Press the Enter key to save the parameters to the flash.

Note 1: The settings are performed using the following parameters.

LCD no.	Parameter	Definition	Initial value
132	X_cmd_pwm_mode	The command input format in the velocity and current modes. (0: Analog / 1: PWM 50% / 2: PWM 100%)	0
85	X_cmd_ext_i_sc	The current command ratio, indicating the corresponding relationship of 1V with ampere, or between the Full PWM and the highest speed. (Unit: (A_amp x 1000)/36=1V or (A_amp x 1000)/36=Full PWM)	0
86	X_cmd_ext_i_dz	Dead band for the current command; the current command is 0 when the input voltage is lower than this setting. Unit: Volt)	0

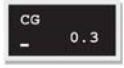
5.3.4 Stand-Alone Mode

Stand-Alone mode is a mode for independent operation. The drive has a high-speed DSP that can perform motion planning by itself. With the support of the DSP, the drive can execute the internal motion program and drive the motor independently without using the external motion control card.

5.3.4.1 Basic setting of Stand-Alone mode

The basic setting of Stand-Alone mode is described below.

Step 1: Mode selection
The steps for selecting Stand-Alone mode on the LCD are described below.

Step	LCD display after operation	Keys to be used	Operation
1			When the drive is powered on, the enable state of the drive is first displayed on the LCD.
2			Press the Function key twice to move to the parameter change mode.
3			Press the Down key three times to move to the operation mode setting screen.
4			Press the Enter key to enter the setting state.
5			The operation mode is set to the Stand-Alone mode by default. It is no need for selection.
6			Press the Enter key to confirm the setting.
7			Press and hold the Up key to move to the SAVE FLSH page. Here the parameters can be saved to the flash memory. This will retain the parameters even if the drive is turned off.
8			Press the Enter key to enter the setting state.
9			Press the Up key to select YES.
10			Press the Enter key to save the parameters to the flash memory.

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6.1 Status display and Quick View

In the Lightening GUI, status display tool and Quick view tool are indispensable assistant tools for adjustment of the machine. They help users understand the system of the drive and display many important values for the motion control.

6.1.1 Status display (Status)

There are 2 status display tools as shown in Fig. 6-1 below. The left figure shows the Status area on the main screen while the right figure shows the Status area in the Performance Center. The status display provides the status and error/warning messages for users to know the system status.

Status:
Hardware Enable Input: To indicate whether the hardware enable signal is on or off.
Software Enabled: To indicate whether the software enable is on or off. Servo Ready: To indicate whether the motor is enable.
Servo Ready: To indicate whether the motor is excited.
Phase Initialized: To indicate whether the phase initialization of the motor is completed.
Moving: To indicate whether the motor is in motion.
Homed: To indicate whether the homing of the motor is completed.
SM mode: Motor enabled in the SM mode.

Errors and warnings:
Last error: The latest error message.
Last warning: The latest warning.
Refer to Chapter 9 "Errors and Warnings" for more information.

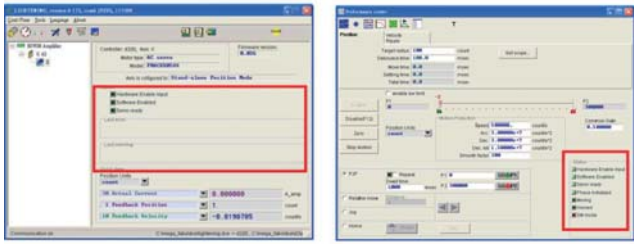


Fig. 6-1 Status display

6.1.2 Quick view

There is a Quick View area at the bottom of the GUI main screen. It provide users to better understand the details of the system status. The interface provides 3 physical value for display. Users can select the physical values to be observed. These values will be updated at real time for users to observe and analyze the system status (Fig. 6-2).

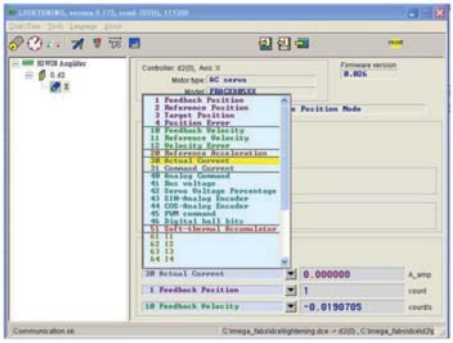


Fig. 6-2 Quick view physical value setting menu

Unit settings (Position Units)
For the change of the position unit, users can select the preferred unit to display the related physical value (position and velocity) as shown in Fig. 6-3..

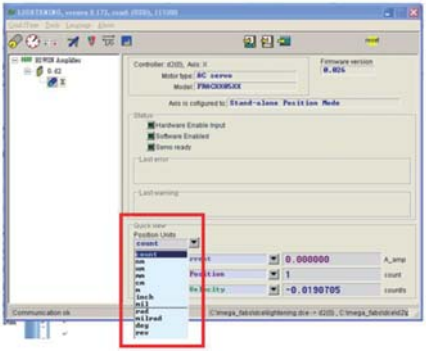


Fig. 6-3 Unit setting menu

6.1.3 Basic common physical value (Basic Variable List)

No.	Physical value	Description
1	Feedback Position	Feedback position
2	Reference Position	Position command
3	Target Position	Target position
4	Position Error	Position error
10	Feedback Velocity	Feedback velocity
11	Reference Velocity	Velocity command
12	Velocity Error	Velocity error
20	Reference Acceleration	Acceleration command
30	Actual Current	Actual current
31	Command Current	Current command
40	Analog Command	Voltage command (from the host controller)
41	Bus Voltage	Line voltage
42	Servo Voltage Percentage	Servo voltage
43	SIN-Analog Encoder	Sine signal of an analog encoder
44	COS-Analog Encoder	Cosine signal of an analog encoder
45	PWM Command	Torque/force/velocity command (from the host controller)
46	Digital hall bits	Digital hall signal
50	Amplifier Temperature	Temperature of the drive
51	Soft-Thermal Accumulator	Temperature estimation of the software
61	I1	Input point 1
62	I2	Input point 2
63	I3	Input point 3
64	I4	Input point 4
65	I5	Input point 5
66	I6	Input point 6
71	I7	Input point 7
72	I8	Input point 8
67	I9	Input point 9
81	O1	Onput point 1
82	O2	Onput point 2
83	O3	Onput point 3
84	O4	Onput point 4
85	CN2_BRK	Onput point 5 (brake signal)

6.1.4 Software shortcuts

There are 2 shortcuts (F6 and F12) on the GUI of the D2 drive. The function is effective only when the Lightening GUI is active in the Windows operating system.
F6: Move the main window of the Lightening GUI to the top.
F12: Emergency stop. For example, click F12 when the motor is in motion to perform the emergency stop, or click F12 to servo off the motor.

6.2 Performance Center

Most of stage turning are performed by using the functions in Performance Center. You can perform a trial run after the auto phase initialization of the motor is completed (Chapter 4).The Performance Center allows users to perform the trail run so that they can make tuning and observe the motion performance by assistant tools.
There are three motion modes in the Performance Center for the trial run. The motion-related parameters, such as velocity, acceleration, deceleration, emergency stop deceleration and smooth factors, are also set here.
The 3 motion modes are:

1. Point-to-Point (P2P).
2. Relative motion.
3. Continuous motion (Jog).

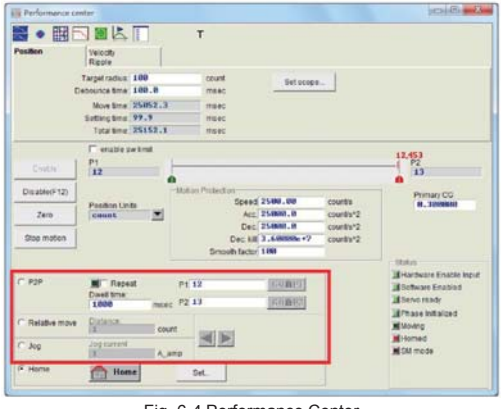
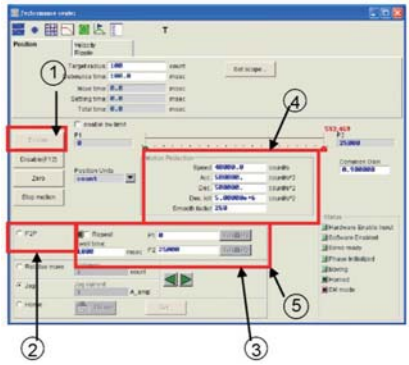


Fig. 6-4 Performance Center

The Point-to-Point (P2P) is used as an example for the following description:

Step	Graphical (HM) description	Operation
1		Click Enable to enable the motor
2		Select P2P
3		Set P1 and P2 positions.(if SW limits are used), set the position between Lower SW limit and Upper SW limit.)
4		Set in the Motion Protection area velocity, acceleration and smooth factor. Refer to 7.1 for more information. The default value can be used if users does not have any special requirements.
5		Click GO P1 to move P1 position and click GO P2 P2 position. If you want to perform a point-to-point motion, check the, enter delay time (Dwell time) and click GO P1 or GO P2 button to perform the Point-to-Point motion.

The Performance Center provides a settling time measuring function. Users can use Target Radius to set the error target radius and debounce time. Refer to 4.5 for more information. User can also adjust the Common Gain during motion to meet requirements of settling time. The higher the Common Gain, the faster the response and the shorter the settling time. Further, user can using the Move Time, Settling Time and Total Time fields to observe the time needed from moving to entering the radius. Click Set scope... to open the graphical oscilloscope (Scope) window, which can be used to observe the motion waveform of the setting time.

The Performance Center provides a velocity ripple measuring function. User can observe the performance of velocity ripple in P2P motion. The Vmax, Vmin, Vavg and Velocity Ripple stand for the maximum velocity, minimum velocity, average velocity and velocity ripple in the uniform motion segment, respectively. Click Set scope... to open the graphical oscilloscope (Scope), which can be used to observe the motion waveform of the velocity ripple.

In addition to the P2P function, the Relative Move is used for setting the distance of the movement and Jog is used for setting the normal or inverse jogging movement. Users only needs to click the ◀ or ▶ button for the setting.

The velocity, acceleration or deceleration and smooth factor set in the Motion Protection area are also used for motion protection. Therefore, if users forgets to set the motion protection values after the test run, the motor may not reach the expected velocity or acceleration when the host controller sends the motion command.

Description of the operation functions on the screen:

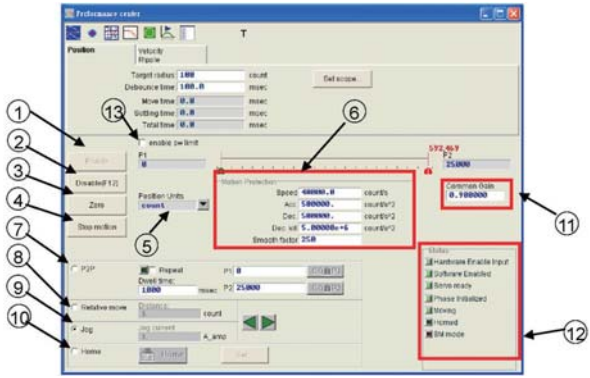


Fig. 6-5 Performance Center - Position page

① Enable: Motor excitation.
② Disable: Motor de-excitation.
③ Zero: Set the current position to zero.
④ Stop motion: Stop the motor.
⑤ Position Units: Set the unit that the use prefers for the operation. This has the same effect as the setting function in Quick View on the main screen.
⑥ Motion Protection: The motion protection parameters of the motor are also the velocity, acceleration, deceleration, emergency stop deceleration and smooth factor for the test run. Users can use the smooth factor to determine the S-curve or T-curve track and the adjustment range is 1~500. The track is closer to an S-curve with a higher adjustment value, and is closer to a T-curve with a lower adjustment value. Refer to 7.1 for more information. Position Units: Setting the unit that users prefers for the operation. This has the same effect as the setting function in Quick View on the main screen.
⑦ P2P: Point to Point.
⑧ Relative move: Relative motion.
⑨ Jog: This stands for a continuous motion. Users can define a current value in the current mode to perform the continuous motion at a constant current.
⑩ Home: Homing.
⑪ Common Gain: The higher the common gain, the higher the servo stiffness. Users can use this value to adjust the servo stiffness. However, if the servo stiffness is too high, the system may become unsteady and cause vibration and electric noise. The stiffness value must be reduced in this case.
⑫ Status Display: Display the status.
⑬ enable sw limit: Enabl the software limit. The function will restrict the travel of the motor.

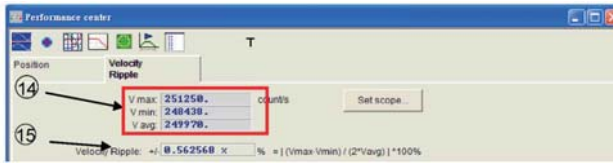


Fig. 6-6 Performance Center - Velocity Ripple page

⑭ V max: The maximum peak value of the velocity ripple.
V min: The minimum peak value of the velocity ripple.
V avg: The average peak value of the velocity ripple.

⑮ Velocity Ripple: Velocity ripple.

6.3 Graphical oscilloscope (Scope)

The D2 drive provides a Scope function for users to observe all physical values during the adjustment of the machine and determine the result of the adjustment. It also allows users to find the cause of the error when the drive is unable to perform its task.

Click the or button in the Performance Center to enter the Scope window. Click on the Position page and Velocity Ripple page to display related physical values. As shown in Fig. 6-7, users can observe the real-time waveform of the physical value after selection of the parameter.

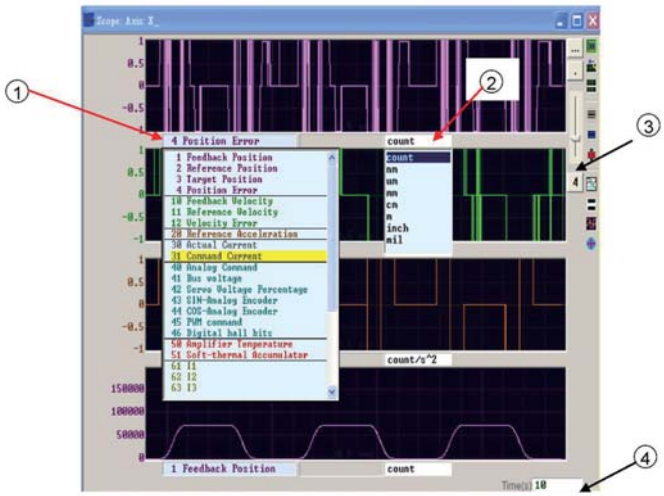


Fig. 6-7 Graphical oscilloscope

① Physical value: Click ① directly to select the physical value to be observed.
② Unit: Click ② to select the unit for the physical value.
③ Number of channels: Click ③ to select the number of channels (1~8) to be displayed simultaneously.
④ Time range of the graphical oscilloscope: Set the time length for a screen on the horizontal axis. Unit: Seconds.

Symbol	Name	Description
	Scope On/Off (PageDown)	The switch of the graphical oscilloscope. When the switch is turned OFF and turned ON again, the graphical oscilloscope will re-retrieve data.
	View in paper mode (Ctrl+T)	Change of the display waveform mode. The Normal and Paper modes are available.
	Toggle scopes window (PageUp)	Display of all selected physical values on a single screen. Click to switch between physical values.
	Fit graph to window	Adjustment of all physical values to a suitable scale.
	Fit graph to window dynamically	Dynamical adjustment of all physical values to a suitable scale.
	Fit graph to window dynamically + clip	Same as the above but the range on the vertical axis can only be increased.
	Show last data with plot view tool	Drawing using the plot view tools based on the data of the graphical oscilloscope.
	Reset scope	The graphical oscilloscope will re-retrieve data.
	Show all plots in same window	All physical values are drawn on the same screen and share the same vertical axis.
	Open recoder window	Connecting the physical value set in the Scope window to the Data Collection function.

6.4 Data collection

In addition to the Scope function for observation of the physical values, there is a tool that offers more setting options for data collection and more advanced graphical display and processing functions. The Data Collection function allows users to set shorter or longer sampling time and provides a conditional trigger mechanism for activation and deactivation of data collection.

6.4.1 Data retrieval (Data Collection)

In the open recorder window (Fig. 6-8), the program automatically picks up the physical value selected on the Scope page for future data collection. The main function is described as follows:

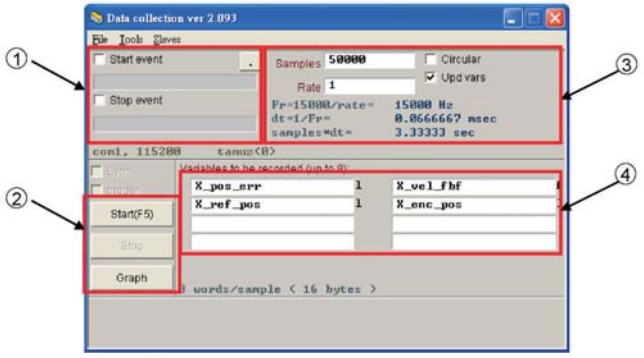


Fig. 6-8 Data collection

1. Automatic collection by condition: For setting the start and stop conditions for data collection.
   For example, to capture the graph of the motion cycle, check Start Event to set to X_run and check Stop Event to set to X_stop. After the setting is completed, click Start to bring Data Collection to the standby state. When the motion of the motor starts, collection of the data begins; when the motion ends, the collection of data stops. When the data collection is completed, click Graph to plot the graph of the motion cycle.
   For example, to retrieve the graph of the velocity cycle, check Start Event to set to X_vel_fb>0 and check Stop Event to set to X_vel_fb<0. After the setting is completed, click Start to bring data collection to the standby state. When the motion speed is more than 0, the collection of the data begins; when the speed is less than 0, the collection of the data stops. When the data collection is completed, click Graph to plot the graph of the velocity cycle.
2. Manual collection button: Click the Start button to start the collection and click the Stop button to stop the collection. Click the Graph button to open the Plot View and draw a graph based on the collected data.
3. Sampling frequency (Rate) and the number of the samples (Samples):
   The sampling counts.
   Rate determines the sampling frequency. For example, when Rate is set to 1, the sampling frequency is 15000Hz and when it is set to 2, the sampling frequency is 7500Hz. The maximum sampling frequency is 15000Hz. If too many data are collected, early finish of the collection may happen due to the limit of the bandwidth. Users can reduce the number of the physical values to be collected to solve this problem. dt is the sampling time. Samples*dt is the total collection time of the data. Users can increase the total collection time by increasing the Samples.
4. The internal variables corresponding to the physical values of the collected data.

6.5 Plot view

The Plot View is a function of the Data Collection. It allows graphs can be drawn based on the data collected in the Data Collection, and provides powerful analysis function for different measurements and operations. There are 4 areas (function menu area, main function key area, physical value display area, graphical frame area) and a timeline scroll bar in the Plot View, as shown in Fig. 6-9.

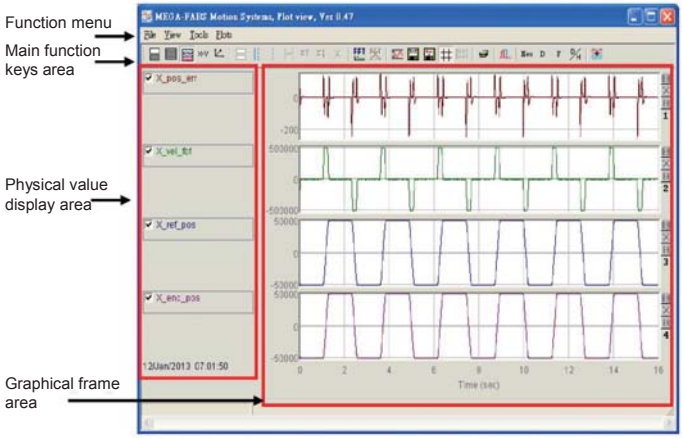


Fig. 6-9 Plot view introduction A

6.5.1 Graphical display mode

The graphical frame displays the number of channels.
The graphical frame area is mainly for displaying the graph of physical values. When the graphs of physical values are collected in the Scope or Data Collection window, all physical values selected by the graphical oscilloscope are shown in the Plot View. Users can adjust the number of the channels for the graphical frame within an upper limit of 8. The icons in the main function keys area are described below:

: Set the maximum number of channels.

: Display a single channel.

To observe the graphs of 2 physical values, click and select 2 graphs to set the number of channels to 2. To observe the graph of 1 physical value, click and select graphs to set the number of the channels to 1. The Fig. 6-10 shows the situation in which only two physical values are selected in the Scope or Data Collection windows.

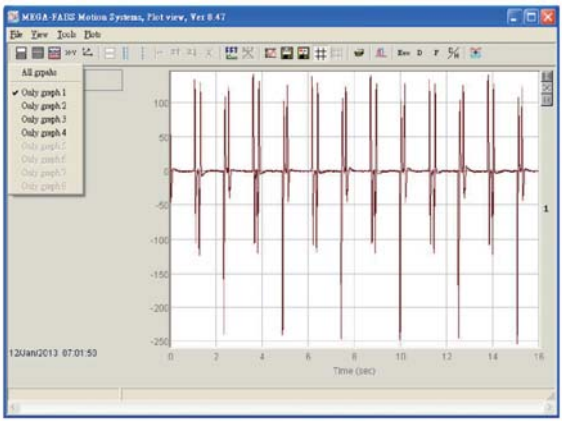


Fig. 6-10 Plot view introduction B

Display or hide physical values
If users unchecks a physical value, the graph of the physical value will be hidden in the graphical frame area. Fig. 6-11 shows that 2 physical values are unchecked. To uncheck all physical values, click the icon in the main function keys area:

: Uncheck all physical values.(Or click the Delete button.)

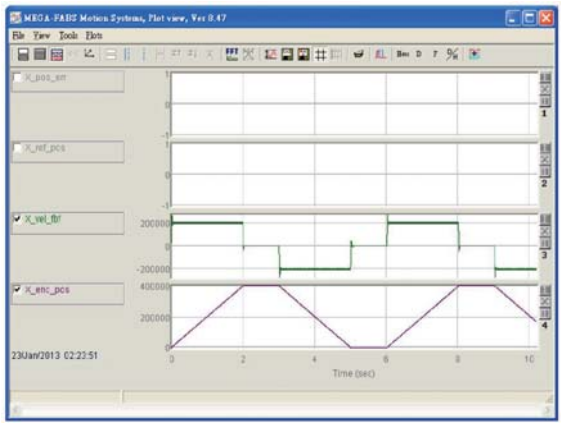


Fig. 6-11 Plot view introduction C

Zoom in/out
To observe the subtle change of a certain segment closely, use the solid-line and dashed-line borders to select the area to be zoomed in. The Plot View allows users to zoom in/ out the X and Y axes. The followings are the icons and operations in the main function menu:

: Zoom in the graph between the blue solid line and dashed line on the X axis.

: Undo zoom.

: Redo zoom.

: Cancel all zoom-in displays.

: Zoom in the graph between the red solid line and dashed line on the Y axis.

: Cancel the zoom-in action on the Y axis.

Zoon in/ out on the X axis:
To zoom in on the physical value graph ranging from 6 to 10 seconds, use the left key to move the blue solid line or use the right key to move the dashed line to frame this segment. Then click to zoom in (Fig. 6-12). To zoom in on a much smaller segment (e.g. 7~9 seconds), repeat the above steps . To see the previous zoom-in segment (6~10 seconds), click . If is clicked again, the zoom-in segment within 7~9 seconds will be displayed. Regardless of how many times you zoom in, use to display the original graph (Fig. 6-13).

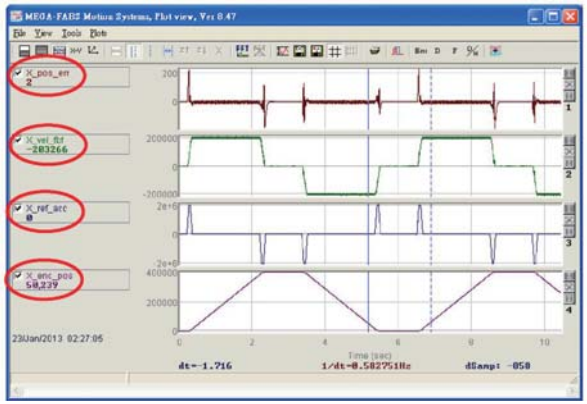


Fig. 6-12 Plot view introduction D

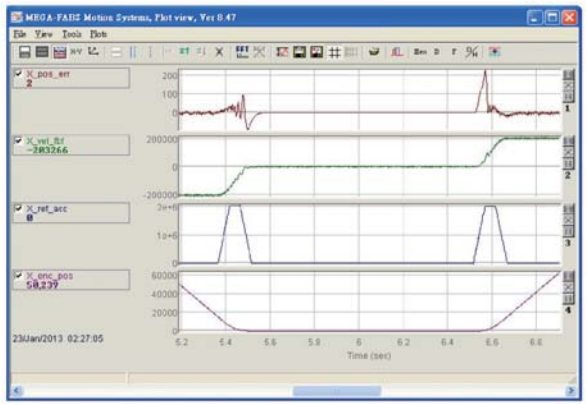


Fig. 6-13 Plot view introduction E

Zoon in/ out on the Y axis:
To zoom in on the Y axis, press and hold the Ctrl+X and left keys to move the red solid line, or the Ctrl+X and right keys to move the red dashed line to select a suitable segment (Fig. 6-14). Then click at the upper right corner of the screen to enlarge the graph within the selected segment on the Y axis (Fig. 6-15). If the values on the Y axis in the graphical frame are locked and shows red, the vertical display range will not be dynamically adjusted when you drag the horizontal scroll bar (Fig. 6-15).

If you click the icon at the upper right corner of the screen, the original graph on the Y axis before the zoom-in will be displayed. Refer to Fig. 6-16 for the illustrated description.

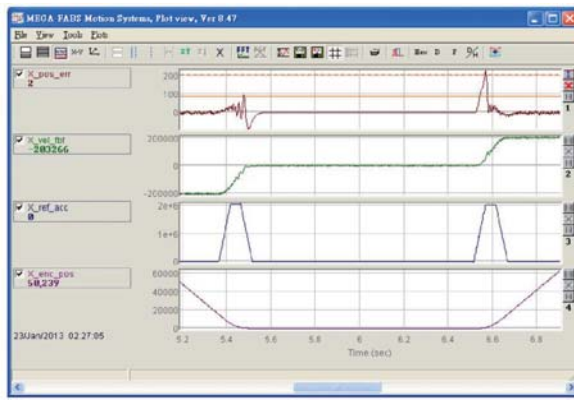


Fig. 6-14 Plot view introduction F

Fig. 6-15 Plot view introduction G

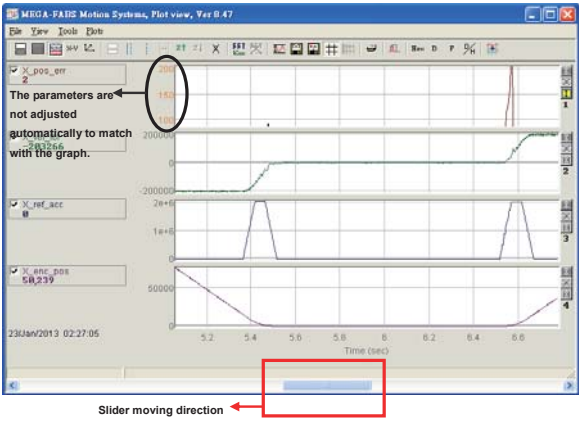


Fig. 6-16 Plot view introduction H

When the area is framed using the blue solid and dashed lines, the value of dt, 1/dt and dSamp will appear at the bottom of the graphical frame area. dt refers to the time in the area and dSamp refers to the sampling numbers in the area.

Display one physical value in different channels
To move the physical value to another channel for display, click the physical value to form a box of dashed line and drag the box to the specified channel.

Physical value display
When the blue solid line moves to a specific time point, a figure that shows the amount of the physical value at this time point will appear below the physical value. The figure is displayed decimally or hexadecimally.

The icons in the main function keys area are as follows:

Hex : Display the value hexadecimally.

D : Display the value decimally.

6.5.2 Save/read files

In the Plot View, the type of the files which can be saved are text files (.txt), picture files (.bmp) and special Plot View files (.gpp). The .txt file is used for saving the figures of all physical values within the retrieving time, while the .bmp file is used for saving the graphs of all physical values as pictures. The .gpp file is the only file which is allowed to be opened in the Plot View. Therefore, if User needs to open a file in the Plot View, remember to save it as a .gpp file. Click the following icons in the main function keys area to save the files as the .txt and .bmp files:

: Save the figures of the physical values as a .txt file.

: Save the graphs of physical values as a .bmp file.

Select Save (Open) in the File function menu to save or read the Plot view .gpp file (Fig. 6-17).

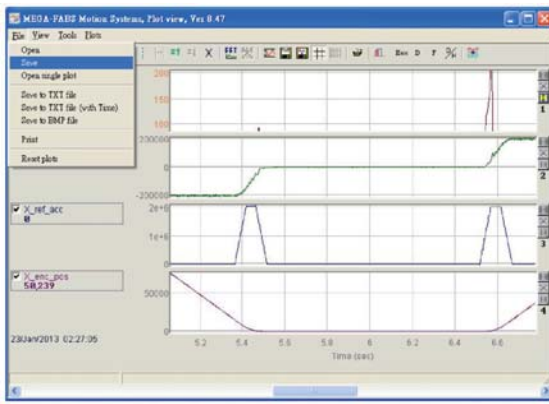


Fig. 6-17 Save as.gpp file

6.5.3 Mathematical operation (Math)

The Plot View also provides the operational function of physical values, such as integration, differentiation, addition and multiplication. It allows User to operate in the Plot View and observe the operational result directly. It also provides the maximum (minimum) of the physical value, ripple calculation and spectrum analysis functions.

Statistics table

Click to show the table in Fig. 6-18. The table shows the maximum (minimum), average, standard deviation (Rms), Rip and RipA of the physical value in the selected segment. Among them, Rip = standard deviation/average and RipA = (maximum-minimum) /average.

Main function icons are as follows:

: The maximum (minimum), standard deviation (Rms) and ripple calculation of the physical value.

Fig. 6-18 Statistics table

Select Tools Math Operation from the function menu or click to open the window (Fig. 6-19). Then select a suitable mathematical operation. In the case of addition, for example, click Linear and select pos_err and vel_fbf from the drop-down list. Then name the new physical value in the "New plot name" field and set the color. Click Create to generate a physical value (lin_1) by adding the pos_err and vel_fbf (Fig. 6-20).Other mathematical operations are same as the addition in the operation method. The icon in the main function keys is as follows:

: Mathematical operation.

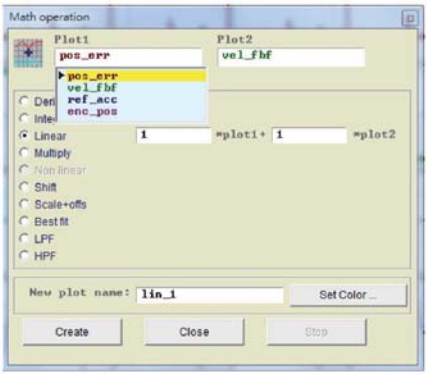


Fig. 6-19 Math operation

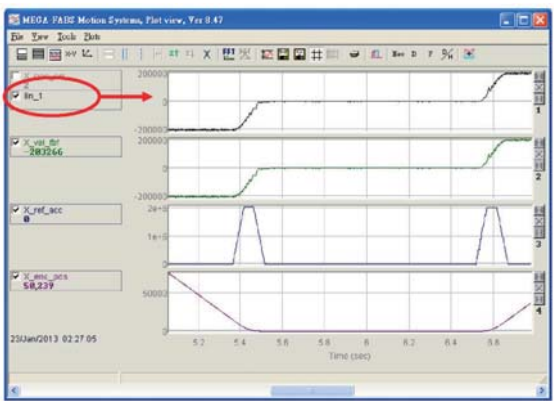


Fig. 6-20 Math operation connected to Plot View

Fast Fourier Transform (FFT):
Click in the main function keys area to open the window as shown in Fig. 6-21. Select a physical value (e.g. pos_err) for implementation of FFT. Click Run FFT to generate the transformed graph as shown in Fig. 6-22. Users can click to cancel FTT. The icons of the main function keys are shown below:

: Implement FFT for a physical value.

: Cancel FFT.

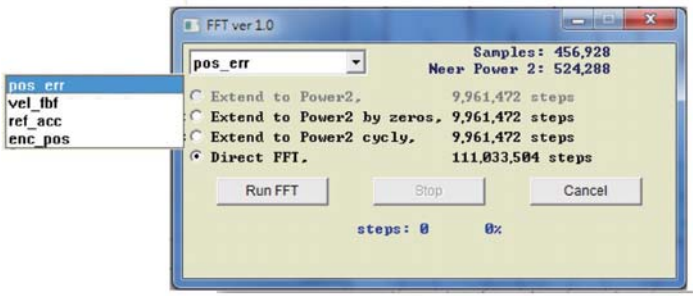


Fig. 6-21 FFT settings

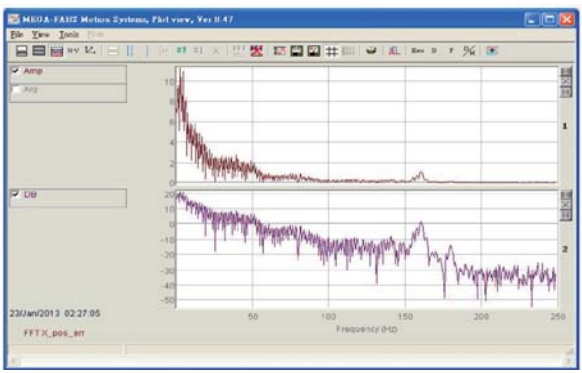


Fig. 6-22 FFT Plot View

Natural logarithm:
The natural logarithm function to express the X axis in logarithmic form and it is only applicable after FFT is completed. Main function icon is as follows:

: Express the X axis in logarithmic form. It is only available after FFT is completed.

6.6 Advanced Gains tuning (Advanced Gains)

Important tasks of the servo drive include the time it takes for the motor to move from start point to the specified position (of Move & Settle), the position error and the velocity ripple. The improvement of these performances is to be achieved through tuning of gains and parameters. Tuning common gain is the simplest way for the D2 drive to improve the motion performance of motor. The higher common gain causes higher servo stiffness. However, if the servo stiffness is too high, it will bring about system vibration or electric noise depending on the mechanical status.

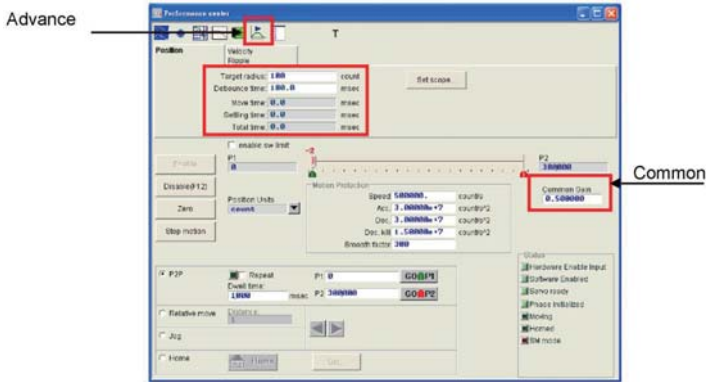


Fig. 6-23 Performance center

The system also provides advanced gain tuning functions in case that the common gain cannot fulfill required performance. These functions include the Filter, Acc feedforward, Gain Schedule, Analog input and current loop.

6.6.1 Filter

The filter is located inside of servo control loop and mainly used to eliminate the problem caused by high frequency vibration of the system or deal with the resonant frequency of the mechanical system to improve the control performance of system. The D2 drive has two filters that can be used concurrently and set as a low pass filter or a notch filter. To design a filter is often done by analyzing the system characteristic in frequency domain. Yser can click the Bode... button in Fig. 6-24 to open the emulated interface of Bode plot. The settings of two commonly used filters are described as follows.

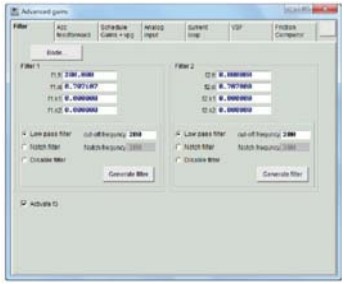


Fig. 6-24 Filter

Low pass filter

A setting of a typical low pass filter is set as follows:

Fr: Cutoff frequency. The unit is Hz. 500Hz can produce an excellent result in general applications and reduction of the frequency can be considered in some cases. However, control performance will be affected if the cutoff frequency is too low.

xi: Damping ratio of the filter. The value ranges from 0 to 1.

k1: 0

k2: 0

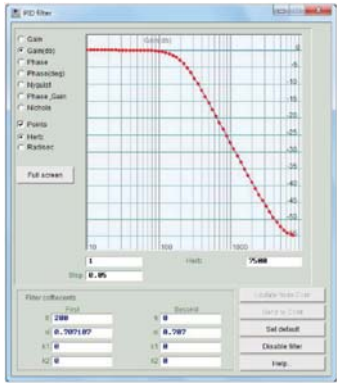


Fig. 6-25 Low pass filter

Notch Filter

When there is an improper resonate frequency in the mechanical system, (e.g., 10~250Hz) and the resonance cannot be eliminated through mechanical correction or design, a notch filter can be used to solve this problem. The setting of a notch filter is usually configured with reference result of the frequency analysis.

A setting of a typical notch filter is set as follows:

Fr: Cutoff frequency. The unit is Hz.

xi: TDamping ratio of the filter. The value ranges from 0 to 1. The band of the filter becomes narrower when the ratio is closer to 0. It becomes wider when the ratio is closer to 1.

k1: 0

k2: 1

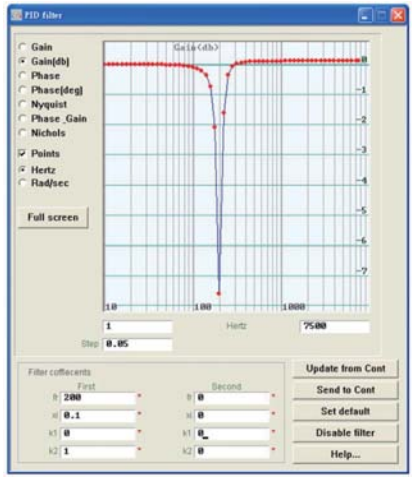


Fig. 6-26 Notch filter

Automatic resonance suppression filter (f3)

The completion of the auto gain tuning will also start the f3 filter. However, when user drives the motor and finds that system vibration is not effectly suppressed by f3 filter,User can uncheck the Activate f3 option (the red frame in Fig. 6-27) in the Filter tab of the Advanced Gains, and manually set up Filter 1 and Filter 2 to suppress resonance effectively.

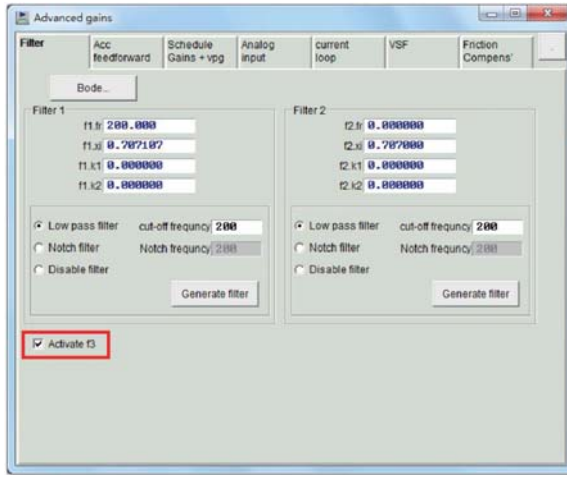


Fig. 6-27 f3 filter

6.6.2 Acceleration feedforward (Acc feedforward)

The position error is usually more significant during acceleration and deceleration, especially when a higher moving mass or moment of inertia is applied. Setting the acc feedforward parameter can effectively reduce the position error during acceleration and deceleration.

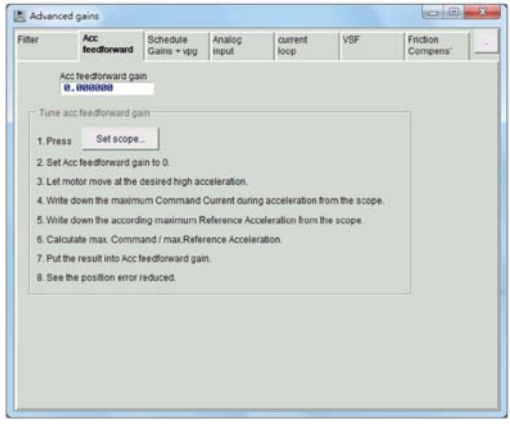
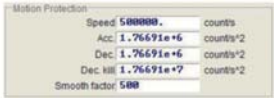
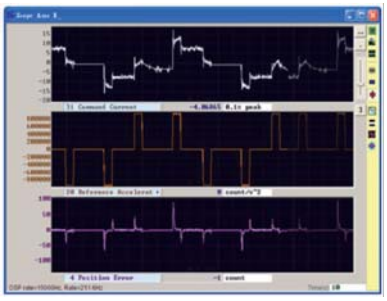

Advanced gains
Filter
Acc feedforward
Schedule Gains + vpg
Analog input
current loop
VSF
Friction Compens'
Acc feedforward gain
0.000000
Tune acc feedforward gain
1. Press
Set scope...
2. Set Acc feedforward gain to 0.
3. Let motor move at the desired high acceleration.
4. Write down the maximum Command Current during acceleration from the scope.
5. Write down the according maximum Reference Acceleration from the scope.
6. Calculate max. Command / max.Reference Acceleration.
7. Put the result into Acc feedforward gain.
8. See the position error reduced.

Fig. 6-28 Acceleration feedforward (Acc feedforward)

The procedure for adjusting the acceleration feedforward are described below:

Step	Graphical (HM) description	Operation
1		Click the Set scope button to show the graphical oscilloscope screen.
2		Set Acc feed forward gain to 0.
3		Set the maximum acceleration as required.
4		Use the P2P function to move the motor back and forth.
5		Record the command value of the maximum current in the acceleration segment. You can see the Command Current is 16 in the acceleration segment in this example.
6		Record the maximum reference acceleration value in the acceleration segment. The reference acceleration is 950,000 count/s^2 in this example.
7		Divide the value in Step 5 by the value in Step 6: Acc feedforward gain=Command Current/Reference Acceleration=16/950000=1.68421 e-5.
8		Enter the result acquired in Step 7 in the "Acc feed forward gain" field.

9		Observe the position error value and you will find it decreases from 90 counts to 65 counts in the acceleration segment.

Step 5 notes
When the motor begins to move, the graph appears on the Scope (Fig. 6-29). You can use the "Toggle scopes windows (Page Up)" button to switch between the graphs of a single physical value. Clicking this button repeatedly will toggle between the graphs of the command current, reference acceleration and position error in sequence, so that users can read the values of these graphs easily.

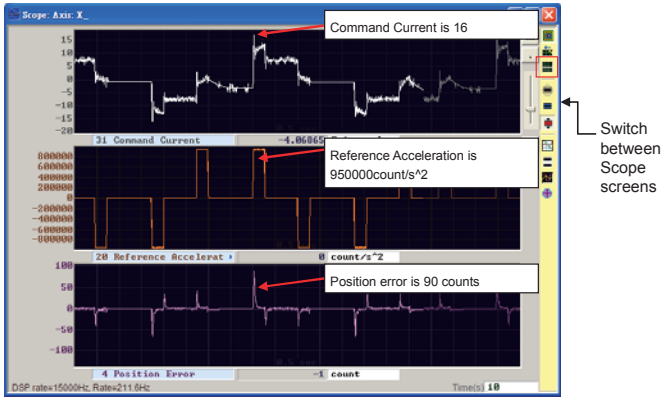


Fig. 6-29 Motion track of the motor

6.6.3 Schedule gains and velocity loop gain (Schedule Gains+vpg)

Schedule gains
A complete motion control can be divided to three stages:
Move: From the start to the end of trajectory planning.
Settling: From the end of trajectory planning to the in-position stage.
In-position: Completion of the position settling.
The purpose of the schedule gain is to adjust the servo stiffness to be output at each motion stage (Move, Settling, In-position) based on the common gain. Adjustment of the gain at each stage is conducted proportionally. The original common gain is used when the setting value is 1 and the gains are reduced when the setting value is less than 1.
The corresponding parameters at each stage:
Move: sg_run
Settling: sg_stop
In-position: sg_idle
If common gain=0.5 and sg_run=1.2, the common gain that is practically used at the Move stage is changed to 0.5*1.2=0.6..
The same is applicable at the Settling and In-position stages. The constant common gain is changed appropriately by using the schedule gain to meet the requirements at different stages.

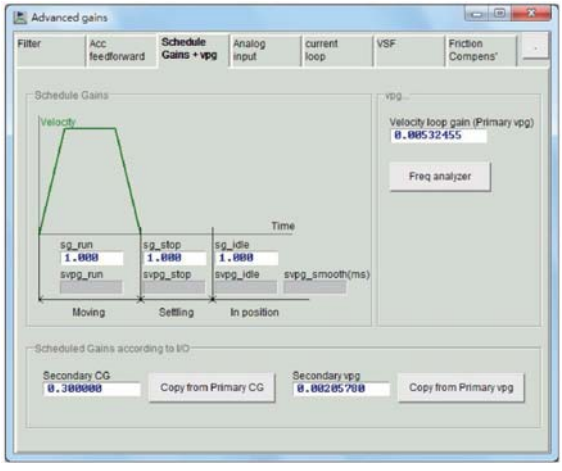
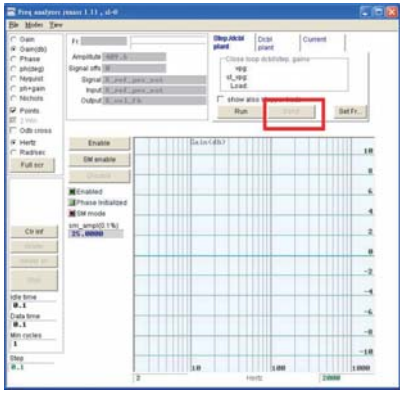
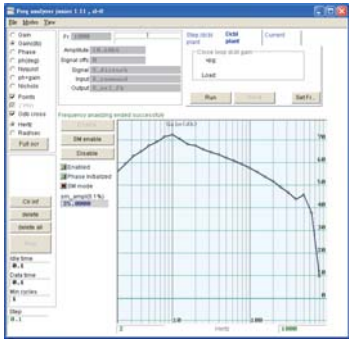
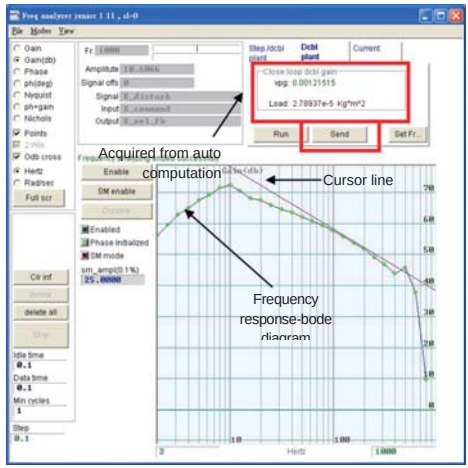


Fig. 6-30 Schedule gains

Velocity loop gain (vpg)
The velocity loop gain (vpg) is an internal control parameter of the D2 drive. The default value is computed by using theparameters user defined in the Configuration Center. Modification of vpg is not needed in general condition, but User can use the Freq analyzer to adjust its value. The steps are as below..

Step	Graphical (HM) description	Operation
1		Click the Freq analyzer button on the page as shown in Fig. 7-30. Then following screen appears.
2		Click the Enable button.
3		Click the Run button to activate the frequency analyzer. Motor vibrates from LF to HF, you may head the HF sound at the end. Then a frequency response diagram appears on the screen.

4		Left click on the frequency response diagram and a line of -20dB appears on the screen. Press and hold left key to drag the line to the position close to the bode diagram as shown in the figure below. The Gain is re-computed during the movement of line, and vpg value is displayed on the screen. The Gain is increased when the cursor line is dragged downward, and decreased when the cursor line is dragged upward.
5		Click the Send button to save vpg value to the RAM of the drive.

6.6.4 Analog input

When in current/velocity mode, the voltage command transmitted from the host controller may have a bias for Many reasons. This may bring about distortion of the command and affect the performance. In this case, the analog input function can be used for bias correction and compensation. User only needs to click the Set Offset (Set Offset) button for system to execute the auto measurement and modify the offset.

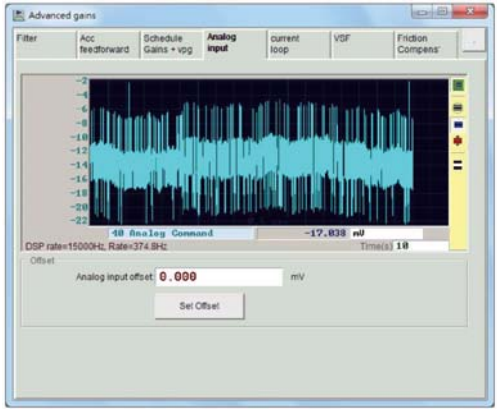


Fig. 6-31 Analog input

6.6.5 Current loop

The gain values (Ki and Kp) of current loop are basically calculated by using the parameters of motor which is selected in the Configuration Center and No adjustment is needed normally. But they can be adjusted by using this function if the parameters of motor were not set correctly. The low pass filter can be set according to the result of frequency response. Noise might be generated if the gain of current loop is set too high. However, this problem can be solved by setting the low pass filter to a lower frequency (e.g. 1000 Hz).

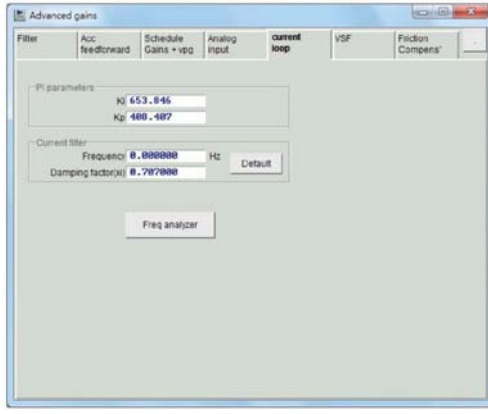


Fig. 6-32 Current loop

6.6.6 Vibration suppression filter (VSF)

The VSF is used to suppress the vibration generated by the motor in motion. The vibration is significant when a cantilever beam is used as the loading mechanism. User can use a vibroscope to measure the vibration frequency at the location where vibration is obvious and enter the measured value in the Frequency column. The "enable VSF" must be checked to enable the VSF. User then needs to move the motor for verification of the effectiveness. When the motor is moving,User can use the VSF factor value (1.0 by default) to adjust the effect of the suppression. The allowable range is 0.7~1.5.

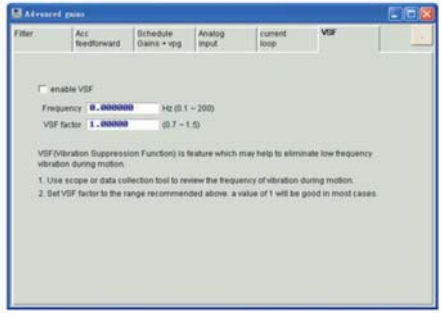

Advanced gains
Filter
Acc feedforward
Schedule Gains + vpg
Analog input
current loop
VSF
enable VSF
Frequency
0.000000
Hz (0.1 ~ 200)
VSF factor
1.00000
(0.7 ~ 1.5)
VSF (Vibration Suppression Function) is feature which may help to eliminate low frequency vibration during motion.
1. Use scope or data collection tool to review the frequency of vibration during motion.
2. Set VSF factor to the range recommended above. a value of 1 will be good in most cases.

Fig. 6-33 Vibration suppression filter (VSF)

6.6.7 Friction compensation

The position error is usually more significant in the period of acceleration and constant speed motion, especially for the use in a higher moving mass or moment of inertia. Setting the friction compensation parameter can effectively reduce the position error in the acceleration period. Fig. 6-34 shows the setting page of the friction compensation.

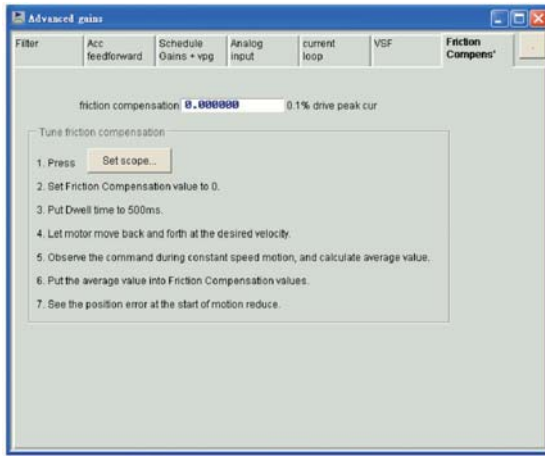
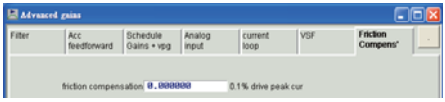
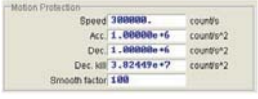
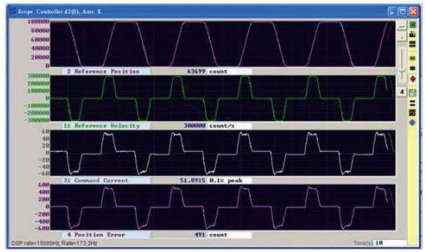
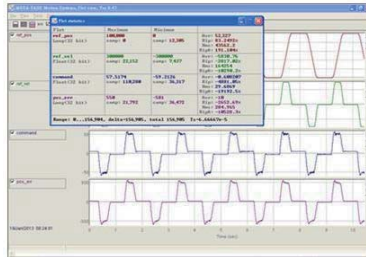
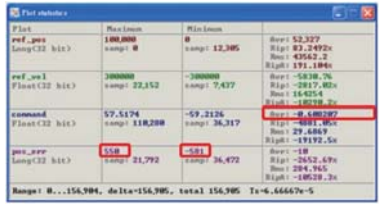
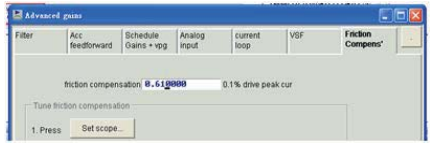
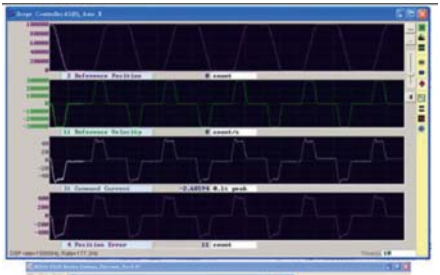
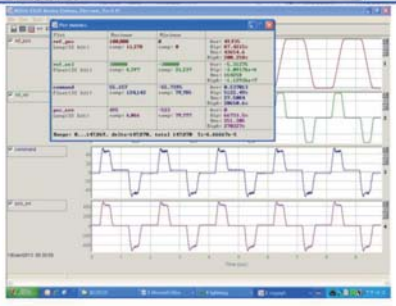

Advanced gains
Filter
Acc feedforward
Schedule Gains + vpg
Analog input
current loop
VSF
Friction Compens'
friction compensation 0.000000 0.1% drive peak cur
Tune friction compensation
1. Press Set scope...
2. Set Friction Compensation value to 0.
3. Put Dwell time to 500ms.
4. Let motor move back and forth at the desired velocity.
5. Observe the command during constant speed motion, and calculate average value.
6. Put the average value into Friction Compensation values.
7. See the position error at the start of motion reduce.

Fig. 6-34 Friction compensation

The operation steps of the friction compensation are described below.

Step	Graphical (HM) description	Operation
1		Click the Set scope button to enter the scope screen.
2		Set the Friction Compensation to 0.
3		Set the desired acceleration.
4		Set the Dwell Time to 500msec. Use the P2P function to move the motor back and forth.

5	  	As the figure shows, the average of the command current is -0.61 and the position error is -581~550 counts.
6		Enter the average command current of Step 5 in the Friction Compensation field.

7	  	Observe the position error value and you will find it decreases from -581~550 to -523~495 counts during the acceleration.

6.7 Encoder signal confirmation

The encoder plays an important role in the servo motor control. It provides the drive with the position or angle information to ensure the servo loop control. In D2 drives, the functionality of the encoder output signal can be checked via the HM interface.

6.7.1 Encoder signal confirmation function

Click on the Performance Center screen or select Tools -> Encoder test/tune in the function menu to open the function window and check the reading or signal of the encoder for anomalies. The function window is shown in Fig. 6-35.

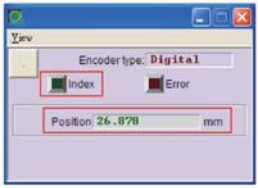


Fig. 6-35 Digital encoder

6.7.2 Encoder reading confirmation

The signal of the digital encoder is comprised of two digital pulses with a phase difference of 90°. Users of the D2 drive can use this function to check the encoder for correct readings by, for example, rotating at a given angle and confirming whether the position reading is same as the angle value.

6.7.3 Index signal confirmation

The Index lamp in 7-33 can be used to confirm the reception of the Z-phase signal. It flashes green once when the drive reads the Z-phase signal.

6.8 Loop constructor

The Loop Constructor function allows users to confirm the stability of the control system. It provides spectrum analysis tools such as Nyquist, Nichols and Bode. In addition to adjusting the filters and gain values (vpg, vig, ppg and CG), users can use this function to change the parameters directly and observe the frequency response of the control system.
To enter the Loop Constructor screen, open the Lightening main screen and select Tools->Loop constructor as shown in Fig. 6-36. Fig. 6-37 shows the Loop constructor interface.

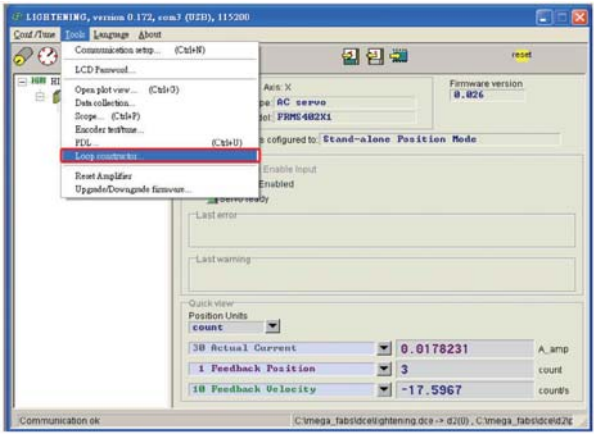


Fig. 6-36 Tools->Loop constructor

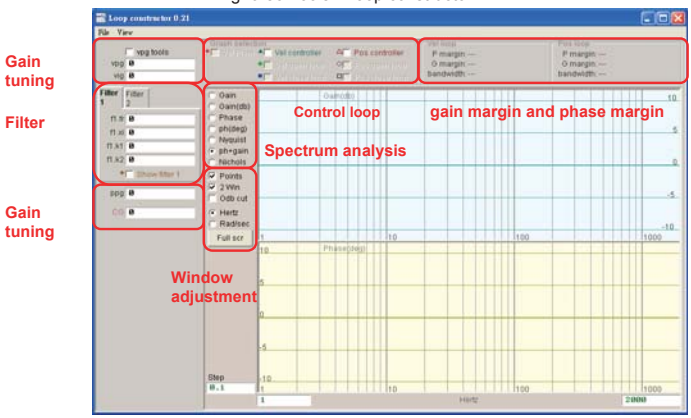


Fig. 6-37 Loop constructor interface

6.8.1 File load/save

When using the Loop constructor function to analyze the control system, users needs to load the control system and gain parameters by selecting File->Load from the Loop Construction interface. There are three kinds of files can be loaded, such as (1) Load plant+gains from file... (2) Load plant from file… (3) Load gains from file… as shown in Fig. 6-38.

(1) Load plant+gains from file…: Load the .lop file. This file contains the control system and gain parameters.
(2) Load plant from file…: Load the .fgr file. This file contains the control system.
(3) Load gains from file…: Load the .gns file. This file contains the control gains.

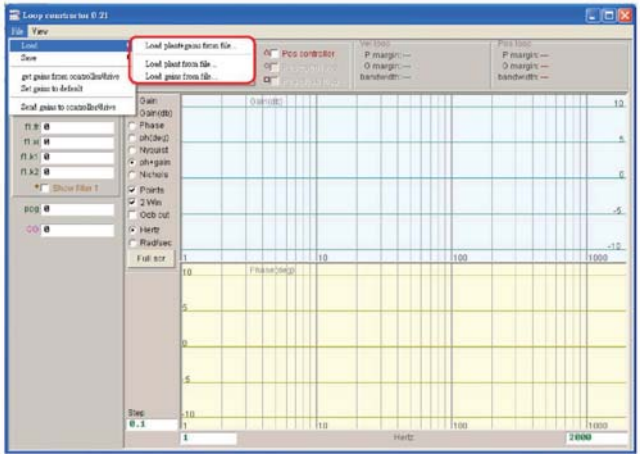


Fig. 6-38 Loop constructor load data from file

When it is needed to save the control system and gain parameters is needed after the loop constructor analysis, users can save them by selecting File->Save from the Loop Construction interface. There are three kinds of files can be saved, such as(1) Save plant+gains to file... (2) Save plant to file… (3) Save gains to file... as shown in Fig. 6-39.

(1) Save plant+gains to file…: Save the .lop file. This file contains the control system and gain parameters.
(2) Save plant to file…: Save the .fgr file. This file contains the control system.
(3) Save gains to file…: Save the .gns file. This file contains the control gain.

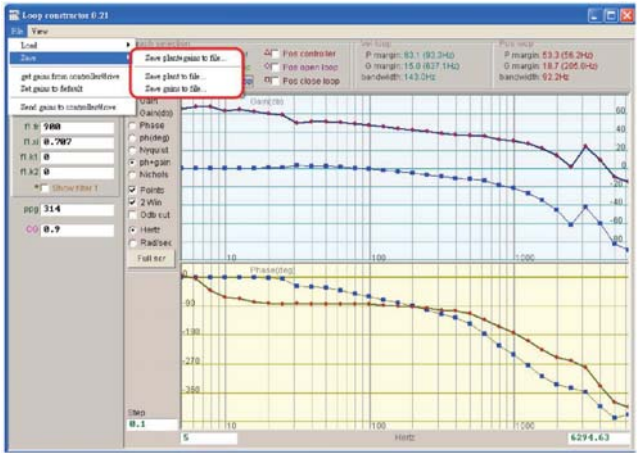


Fig. 6-39 Loop constructor save data to file

6.8.2 Tool

The spectrum analysis provided by the Loop Constructor function can analyze the Nyquist, Bode and Nichols plots of the emulated control system and generate frequency responses.

6.8.2.1 Frequency response function

The frequency response can be represented by the transfer function of a dynamic system and indicates the relative relationship between the input and output signals of that system. Fig. 6-10 shows the control structure of the drive.

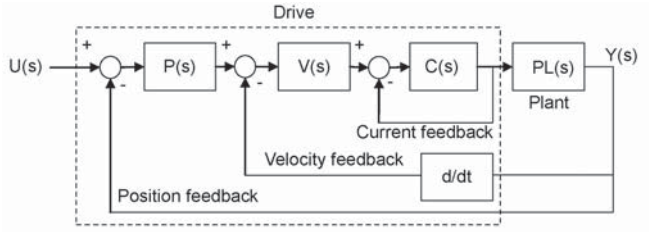


Fig. 6-40 Control structure of the drive

U (s): System input. Here it stands for a command from the drive.
Y (s): System output. Here it stands for a position feedback from the encoder.
Plant: PL(s) represents the relationship between the drive command and feedback position. This Plant contains the mechanical platform, motor and feedback system.
Controller: P(s) is the position loop controller, V(s) is the velocity loop controller and C(s) is the current loop controller.
Open loop: The transfer function of the open loop system is G(s) =P(s)*V(s)*C(s)*PL(s), meaning to ignore all feedback signals.
Close loop: The transfer function of the close loop is T(s)=P(s)*V(s)*C(s)*PL(s)/((d/dt*P(s)*V(s)*C(s)*PL)+P(s)*V(s)*C(s)*PL(s)).

6.8.2.2 Nyquist

The Vel open loop (velocity open loop) and Pos open loop (positionopen loop) of the emulated control system can be analyzed on the Nyquist plot for their frequency responses. You can analyze the emulated velocity or position open loop by checking the Nyquist plot. Analyzing two loops simultaneously is also possible. Fig. 6-41 shows the Nyquist plot of the velocity open loop. When you click the curve on the Nyquist plot, the frequency response value will be displayed for analysis of the control system.

(1) Vel open loop: The frequency response of the velocity open loop

(2) Pos open loop: The frequency response of the position open loop

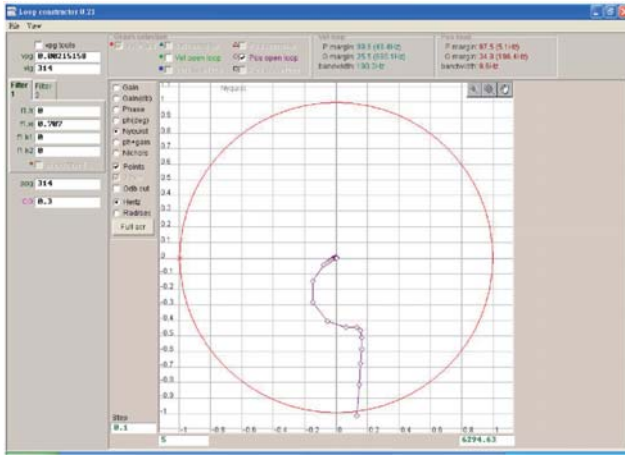


Fig. 6-41 Nyquist plot of the velocity open loop

6.8.2.3 Bode

The Vel controller, Vel open loop, Vel close loop, Pos controller, Pos open loop and Pos close loop of the emulated control system can be analyzed on the ph+gain plot for their frequency responses. You can analyze the emulated velocity or position loop by checking the Bode plot. Analyzing six loops simultaneously is also possible. Fig. 6-42 shows the Bode plot of the velocity open loop. When you move the cursor over the curve on the Bode plot, the frequency response value will be displayed for analysis of the control system.

(1) Vel controller (Velocity controller): The frequency response of the velocity controller
(2) Vel open loop (Velocity open loop): The frequency response of the velocity open loop in the control system
(3) Vel close loop (Velocity close loop): The frequency response of the velocity close loop in the control system
(4) Pos controller (Position controller): The frequency response of the position controller
(5) Pos open loop (Position open loop): The frequency response of the position open loop in the control system
(6) Pos close loop (Position close loop): The frequency response of the position close loop in the control system

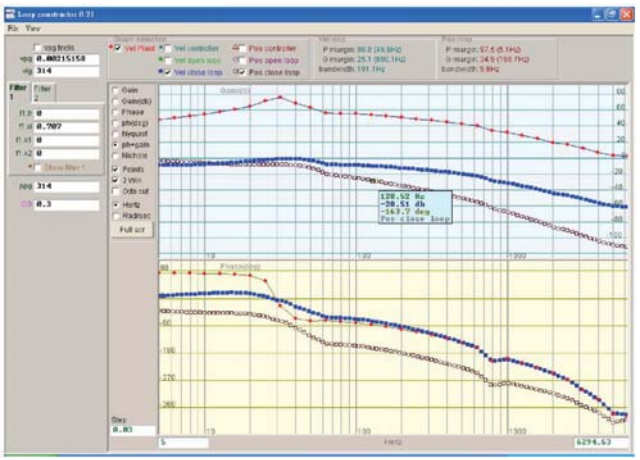


Fig. 6-42 Bode plot of the velocity and position close loops

6.8.2.4 Nichols

The Vel open loop and Pos open loop of the emulated control system can be analyzed on the Nichols plot for their frequency responses. You can analyze the emulated velocity or position open loop by checking the Nichols plot. Analyzing two loops simultaneously is also possible. Fig. 6-43 shows the Nichols plot of the velocity open loop. When you click the curve on the Nichols plot, the frequency response value will be displayed for analysis of the control system.

(1) Vel open loop (Velocity open loop): The frequency response of the velocity open loop in the control system

(2) Pos open loop (Position open loop): The frequency response of the position open loop in the control system

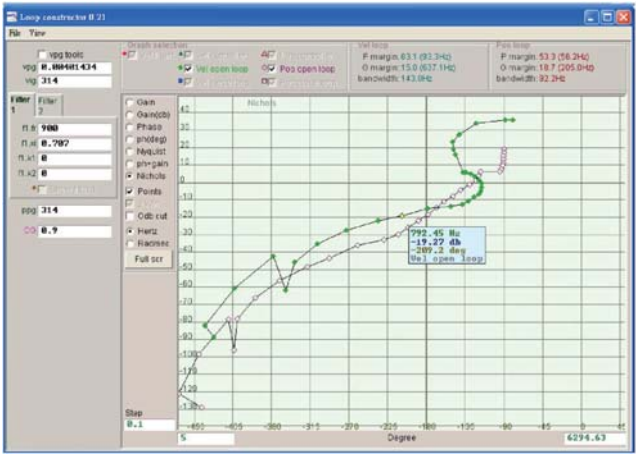


Fig. 6-43 Nichols plot of the velocity and position open loops

6.8.3 Filter

The control loop of the drive provides two filters to deal with HF noise, machinery vibration and deficient structure rigidity.

6.8.3.1 Low pass filter

The low pass filter is used to deal with HF noise and machinery vibration. Fig. 6-44 shows the Bode plot of a low pass filter. Modification of the filter parameters (fr, xi) may affect the frequency response used for the control loop analysis. The emulated control system in combination with the frequency response of the low pass filter is very helpful in real applications.

(1) fr: The cutoff frequency of the filter (unit: Hz). 500Hz can produce an excellent result in general applications and lower frequency can be considered in other applications. However, the control performance will be affected if the cutoff frequency is too low.

(2) xi: The damping ratio of the filter. The value ranges from 0 to 1.

(3) k1: Low pass filter=0.

(4) k2: Low pass filter=0.

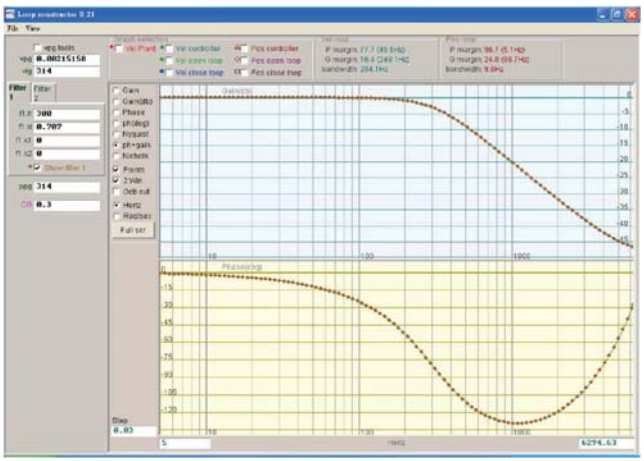


Fig. 6-44 Low pass filter

6.8.3.2 Notch filter

The notch filter is used when a resonant frequency exists in a system and cannot be eliminated by modifying the system mechanism. Fig. 6-45 shows the Bode plot of a notch filter. Modification of the filter parameters (fr, xi) may affect the frequency response used for the control loop analysis. The emulated control system in combination with the frequency response of the notch filter is very helpful in real applications.

(1) fr: The cutoff frequency of the filter (unit: Hz).

(2) xi: The damping ratio of the filter. The value ranges from 0 to 1. The band of the filter becomes narrower when the ratio is closer to 0. It becomes wider when the ratio is closer to 1.

(3) k1: Notch filter=0

(4) k2: Notch filter=1

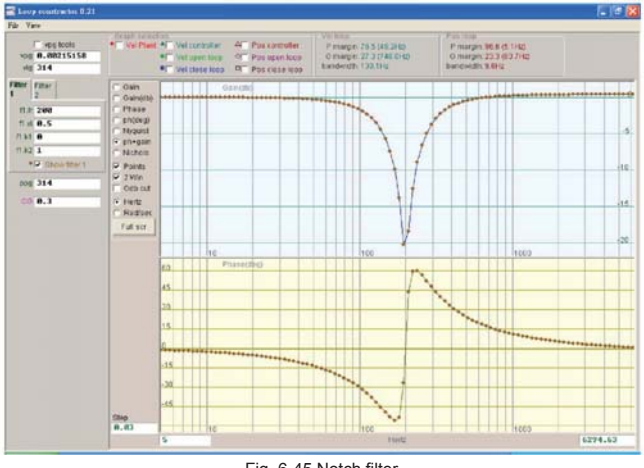


Fig. 6-45 Notch filter

6.8.4 Gain tuning

Loop constructor provides gain values and common gains (CGs) for the velocity loop (vpg, vig) and position loop (ppg). Please refer to 6.6 for more information about VPG and CG. These parameters can be used for gain tuning to emulate the stability of the system after the tuning (Fig. 6-46).

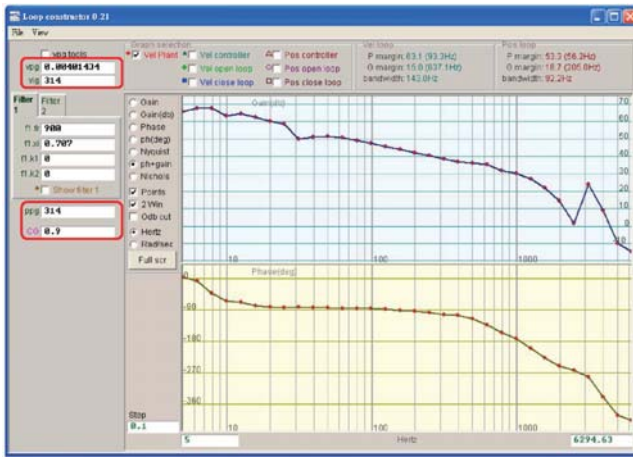


Fig. 6-46 Loop constructor gains

6.8.4.1 Velocity loop

vpg is the proportional gain and vig is the integral gain. Both are the gains for the velocity loop.

(1) **vpg**: Adjustment of the vpg value many affect the transient response of the velocity loop and increase its bandwidth.

(2) **vig**: Adjustment of the vig value may affect the steady state error of the velocity loop, and excessive adjustment may affect the stability of the system.

6.8.4.2 Position loop

ppg is the proportional gain for the position loop.

(1) **ppg**: Adjustment of the vpg value many affect the transient response of the position loop and increase its bandwidth.

6.8.5 Spectrum analysis

Loop constructor provides gain margin, phase margin and bandwidth settings for the velocity and position loops. These parameters can be used for gain tuning to emulate the stability of the system after the tuning. In Fig. 6-47, P margin means phase margin, and G margin means gain margin.

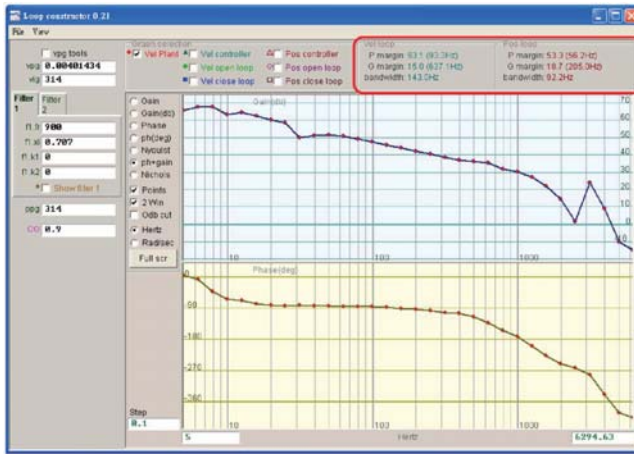


Fig. 6-47 Loop constructor: P margin and G margin

6.8.5.1 Gain margin and phase margin of Nyquist

The gain margin is the loop gains (db) that can be added before the close loop system becomes unsteady. The phase margin is the amount of the phase delay that can be added before the close loop system becomes unsteady.

Gain margin:
The relative distance from the intersection of Nyquist with the negative real axis to the (-1, *j0*) point is represented by $G(j\omega)$; and ω_p stands for the frequency at the phase crossover. Fig. 6-48 shows $\angle G(j\omega_p) = 180^\circ$. For the transfer function G(S) in a loop system:

Gain margin = GM = $20\log_{10}\frac{1}{|G(j\omega_p)|} = -20\log_{10}|G(j\omega_p)|$ dB

The following results are derived from Fig. 6-48 and the characteristics of Nyquist:

(1) If $G(j\omega)$ does not intersect with the negative real axis, then $|G(j\omega_p)| = 0$ and $GM = \infty\ dB$. If Nyquist does not intersect with the negative real axis at any finite frequency, then $GM = \infty\ dB$. Theoretically, the loop gain can be magnified infinitely before the insteadbility occurs.

(2) If $G(j\omega)$) intersects with the negative real axis between 0 and -1, then $0 < |G(j\omega_p)| < 1 \quad GM > 0\ dB$. If Nyquist intersects with the negative real axis between 0 and -1 at any frequency, the gain increases and the system is steady.

(3) If the $G(j\omega)$ is at the (-1, *j0*) point, then $|G(j\omega_p)| = 1 \quad GM = 0\ dB$.If Nyquist $G(j\omega)$ is at the (-1, *j0*) point, then GM = 0dB. This means that the system has become unsteady and the loop gain cannot be increased any more.

(4) If $G(j\omega)$ passes through the (-1, *j0*) point, then $|G(j\omega_p)| > 1 \quad GM < 0\ dB$. If Nyquist $G(j\omega)$ passes through the (-1, *j0*) point, then GM is -dB and the loop gain must reduced by GM to ensure the steadiness.

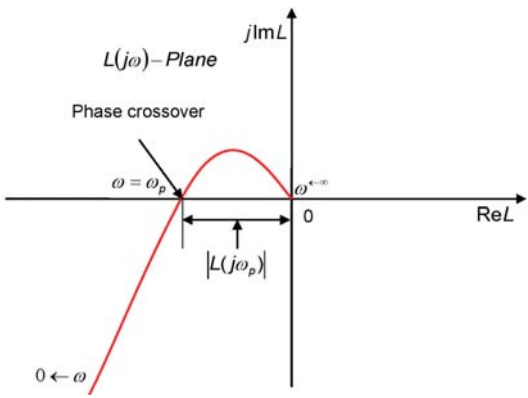


Fig. 6-48 Gain margin of Nyquist

Phase margin:
In Fig. 6-49, the phase margin is the included angle form by the straight line passing through the phase crossover and the negative real axis on the $G(j\omega)$ plane.

Phase margin = PM= $\angle G(j\omega_p)$-180°

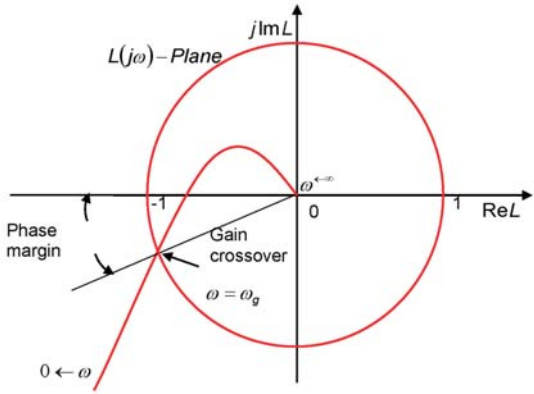


Fig. 6-49 Phase margin of Nyquist

6.8.5.2 Gain margin and phase margin of Nyquist

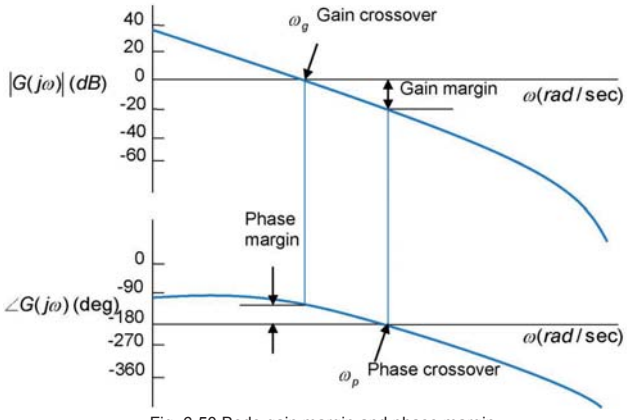


Fig. 6-50 Bode gain margin and phase margin

6.8.6 Bandwidth

The Bode bandwidth is defined to -3dB as shown in Fig. 6-51.

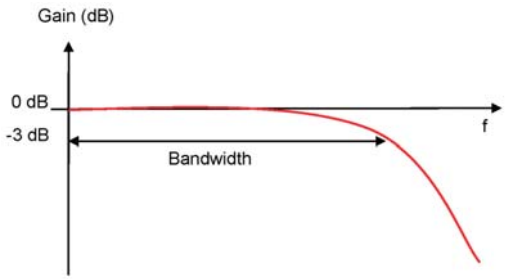


Fig. 6-51 Bandwidth

7 Protection

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7.1 Motion protection

7.1.1 Function overview

It is mainly for restricting (or designating) the maximum velocity, maximum acceleration (deceleration) and emergency stop deceleration of motor output in motor motion. When the host controller is used, the protection function will be activated and the motion features will be restricted within the set limit value if the responding velocity and acceleration of the pulse or voltage commands sent by the host controller is too big. The drive has different protection functions for different operation modes. The followings are the suitable parameters for all modes:

Table 7-1

Limit parameter / Operation mode	Velocity	Acceleration	Deceleration	Emergency stop deceleration
Position Mode	O	O	O	O
Velocity Mode	O	O	O	O
Force/Torque Mode	O	X	X	X
Stand-Alone Mode	O	O	O	O

Note: "○" means active and X means inactive.

7.1.2 Velocity, acceleration and deceleration limits

Click to enter "Performance Center" which shows the settings of motion protection.

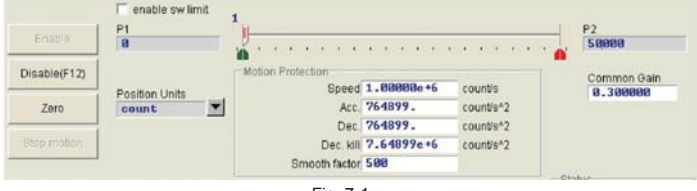


Fig. 7-1

Table 7-2

Parameter name	Description
Speed	Set the maximum velocity of the motor in the motion
Acc.	Set the maximum acceleration that the motor outputs in the motion
Dec.	Set the maximum deceleration that the motor outputs in the motion
Dec. kill	Set the deceleration that the motor emergency stop
Smooth factor	Smooth factor

You can also click to enter "Protection Center" and observe the same group of motion protection settings in "Motion Protection" on the "Protection" tab. The settings can only be displayed, not written.

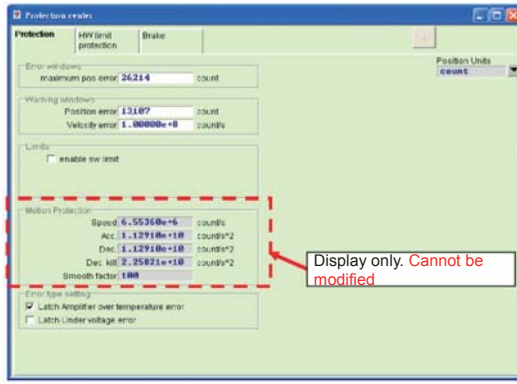


Fig. 7-2

In the Motion Protection area (Fig. 7-2), you can set the maximum velocity, acceleration and deceleration for motion. Click Position Unit to set units according to userss' preference. These settings are used in motion protection and the parameter for the testing run. Therefore, users must confirm whether Motion Protection is set in accordance with users's settings after using P2P, Relative Move, JOG and other motion functions in the Performance Center.

When using the host controller to send motion commands (i.e., operating in the Position Mode, Velocity Mode or Force/Torque Mode), it is strongly suggested that users set Acc. and Dec. to 10 times the value of expected acceleration or deceleration to avoid the restriction of motion protection. If you ignore the action and use the host controller to send motion commands, the expected acceleration or deceleration may be not reached.

7.1.2 Cancelation of velocity, acceleration and deceleration limits

In the Position Mode, the velocity, acceleration and deceleration fields in the Motion Protection of the Performance Center will be greyed out to show that the velocity, acceleration and deceleration are cancelled when the Smooth Factor is set to 0. At this time, the motor moves completely according to the pulse command of route planning from the host controller and users can decide whether to cancel the drive limit function based on needs.

7.1.4 Applicability of emergency stop deceleration (Dec.kill)

The emergency stop deceleration (Dec. kill) will be activated in the following situations:
① In the Position and Velocity Mode, the rotating motor will stop emergently at Dec. kill deceleration when being disabled.
② After users chooses "P2P" and "Relative Move" motion on the "Performance Center" tab and presses Stop Motion (Stop motion).
③ After home is found during homing procedure.
④ When the JOG motion stops.
Dec.kill is used for high deceleration. Thus, it is suggested using the maximum capacity of the motor to set Dec.kill. The formula is described as follows:
Peak current=min (motor peak current, drive peak current)
Linear: Dec.kill= (peak current x force constant) /Total mass of a moving objects
Rotation: Dec.kill= (peak current x torque constant) /load inertia

7.1.5 Smooth motion

The smooth motion is used to lower the impact of motor force on load in the acceleration and deceleration segment during motion. The purpose can be met by setting the smooth factor. The value of a smooth factor is between 0 to 500. The higher the value, the less the impact. A value of 1 means that the smooth function is not active. When a higher smooth factor is used, in some cases the reduced output force of the motor is helpful for the final settings during the positioning process. However, the move time will unavoidably increase when the motion becomes smoother. Henceforth, tests on the machine are needed to adjust the smooth factor and reach a balance.

The motion protection function of the drive can be disabled when the smooth factor is set to 0. Moreover, the smooth factor is only effective and can only be set when the drive is operated in the Position and Stand-Alone Mode. The factor is ineffective and the velocity mode and the Force/Torque Mode.

7.2 Position and velocity error protection

7.2.1 Position error limits

The position error exists in the servo control. When motor moves, the position error becomes bigger. And some external factors may make the position error abnormally big, such as the high friction caused by bearings or linear guideways on machinery for lack of lubricators, winding or overly tight chains in the case tray, foreign objects in the motor stroke, motor clashing foreign objects or stops, the abnormal position encoder or interference. For all abnormalities that lead to bigger position errors, an Error Window is configured in the D2 drive. When the position error exceeds the Window, the drive will generate an error message of "Position Error Too Big", start the emergency stop procedure, send the brake signal and disable the motor. Refer to the Maximum Pos Error Settings in 7.2.2 for more information.

7.2.2 Position and velocity error warning

In addition to the above-mentioned settings of the position error limits, the D2 drive also has the pre-warning function. When the Position Error and Velocity Error exceed the setting in the "Warning Windows", the warning will show in the Status column on the main screen to remind users of the abnormality.

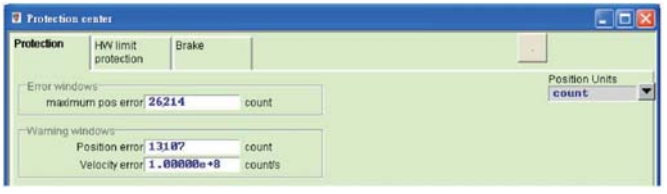


Fig. 7-3

Table 7-3

Parameter name	Description
Maximum pos error	Maximum position error limit value
Position Error	Position error warning value
Velocity error	Velocity error warning value

7.3 Brake output

7.3.1 Function overview

In order to protect the motor and the system structure, the D2-series drive provides a brake signal output for actuating the external electromagnetic brake. It is commonly used in the actuation of motor in Z direction. There are some sequential motion issues in this application. For example, When motor moving in Z direction at great speed receives disable command from drive and activates brake directly, it will cause huge vibration and damage in machinery. Moreover, if disabling motor too early, the machinery and motor may slide down. The D2 drive has the exclusive brake parameter to reduce the aforesaid risks.

7.3.2 Brake/stop sequence

After the drive receives the hardware input signal or the software disables, the following sequential actions will begin:

Step 1. In counted, the brake will be activated after the delay time (delMaxEnToBrk) which starts from receiving the disable command by the drive. However, if the motor decelerates to the brake starting velocity (vel_stop), the brake will be activated first.

Step 2. The post-stage power will be shut down and the motor will be disabled after the setting brake time (delBrkToDis), which is counted from the activation of the brake. The purposes are for the complete brake action counted.

Table 7-4

Parameter name	Description
Brake starting delay time (delMaxEnToBrk)	The maximum time from receiving the de-excitation command to activate the brake
Emergency stop deceleration (Dec. kill)	The deceleration of the motor brake in the emergency stop. Refer to 7.1.4.
Brake starting speed (vel_stop)	The speed for activating the brake after the disable command is received.
The brake acting time (deBrkToDis)	The delay time from activating the brake to shutting down the post-stage current.

7.3.3 Settings

Click to enter "Protection Center". Select the "Brake" tab to open the brake setting page. Users can use the Set.. button on this page to set the brake output pin. The default pin is CN_BRK and no modification is needed. Click the button to show the IO Set/test (IO setting) setting window. Refer to 4.4.2 for the information about the settings.

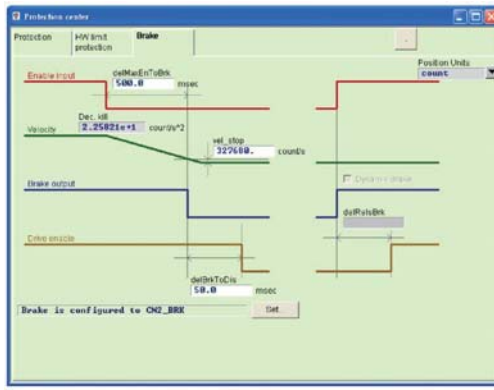

Protection center
Protection
HW limit protection
Brake
Position Units
count
Enable input
delMacEnToBrk
500.0
msec
Dec. rate
2.2582e+1
counts/s^2
Velocity
vel_stop
32768.
counts
Brake output
Drive enable
delBrkToDis
50.0
msec
Brake is configured to CN2_BRK
Set

Fig. 7-4

7.4 Hardware limit protection

7.4.1 Function overview

The D2 drive has hardware limit protection. The hard limit is usually the photoelectric switch or minor vibration switch installed on the positioning platform by users in order to identify the mechanic motion stroke. When the motor collides hardware limit, the protective measure of the emergency stop will be activated. The hardware limit switch is usually the close sensor. When the hardware limit switch is turned on, motor will stop emergenctly at Dec. kill deceleration. After that, the drive can only accept the motion command in the opposite direction.

7.4.2 Settings

After clicking to enter "Protection Center" and select the "HW Limit Protection" tab to open the hardware limit setting page. If you want to activate the hardware limit, check Enable HW Limit ( ). Users can use the Set... button on this page to set the hardware limit output pin. Click the button to open the IO Set/test ( ) setting window. Refer to 4.4.2 for the information about the settings.

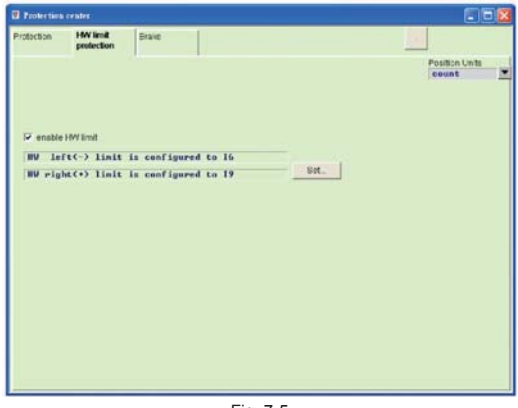


Fig. 7-5

7.5 Software limit protection

7.5.1 Function overview

Except for the hardware limit protection, users of the D2-series drive can also select the software limit protection which serves as the same function of protecting the stroke. When the motor stops at the coordinate of the software limit, the drive can only accept the command to move in the opposite direction.

7.5.2 Settings

After clicking to enter "Protection Center", select the "Limits" menu on the "Protection" tab to show the software limit setting screen. Users must check the enable sw limit (enable sw limit) option before setting the upper and lower software limits. In addition, you can check Enable Sw Limit (enable sw limit) in the Performance Center to activate the software limit protection.

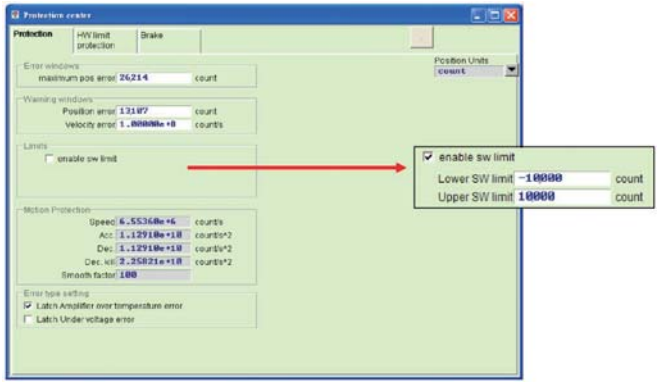


Fig. 7-6

Table 7-5

Parameter name	Description
enable sw limit	For activating the software limit. Check to activate.
Lower SW limit	Lower SW limit position
Upper SW limit	Upper SW limit position

7.6 Soft-Thermal

7.6.1 Function overview

The D2-series drive also has the software to estimate the motor temperature in addition to the motor over temperature protection. The current output is used to calculate the motor power that is used to estimate the motor temperature. When reaching the drive default value, the drive will send error messages (Error: Soft-thermal threshold reached), begin the emergency stop procedure and disabled. Select "Soft-thermal Accumulator" in the Quick View to see the current estimated motor temperature.

7.7 Drive over temperature protection

7.1.1 Function overview

The D2-series drive has a protection function to detect drive ove temperature. When the drive temperature reaches 80 °C, an error message will appears (Error: Amplifier over temperature) and the motor stops running. Select "Amplifier Temperature" in the Quick View to see the current drive temperature.

7.8 Drive overvoltage protection (regen resistor)

7.8.1 Function overview

When the motor decelerates, the kinetic energy is converted to thermal energy for consumption. The remaining energy will be used for drive capatitor charging. However, if the energy exceeds the capacity of the drive capacitor, the energy must be consumed on the regen resistor in the regen circuit in order to protect the drive. The turn-on voltage of the D2 drive regen resistor is 370Vdc while the turn-off voltage is 360Vdc. Users can refer to the following characteristics figure of motor specifications to determine whether the regen resistor is necessary. Take 200W as an example. If users operates at the maximum velocity of 3000rpm and the load inertia exceeds 0.00032Kg-m^2, a regen resistor is necessary. Refer to Table 7-6 for the selecting the model number of a suitable regen resistor.

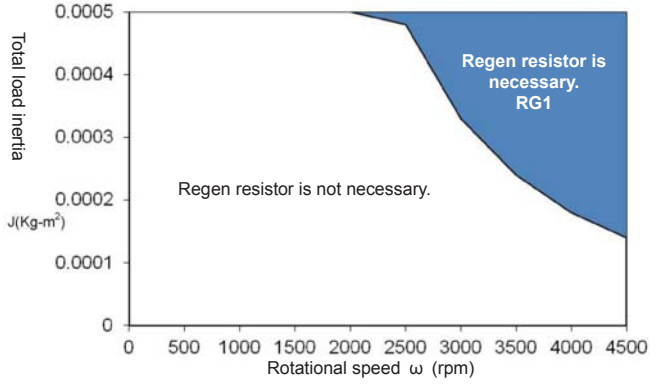


Fig. 7-7 FRMS202XXXXXmotor regen curve

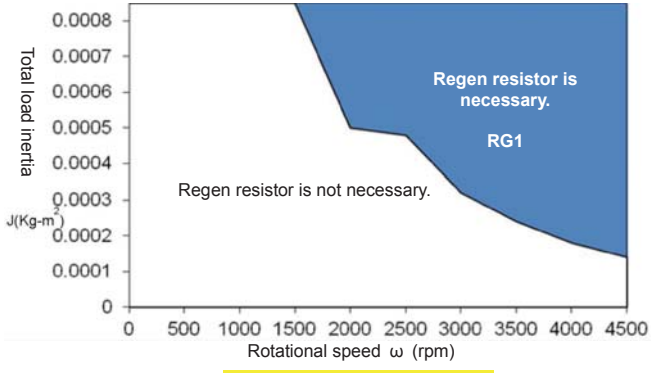


Fig. 7-8 FRMS402XXXXXmotor regen curve

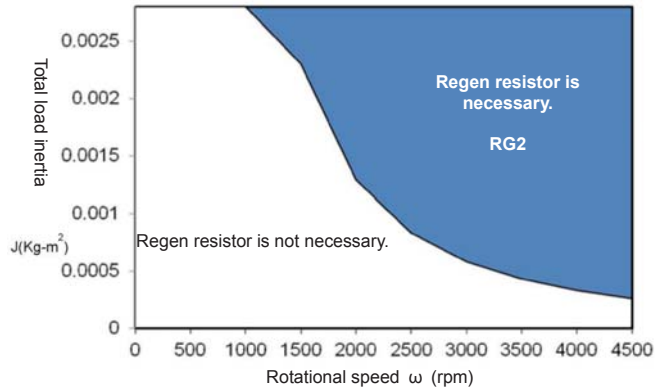


Fig. 7-9 FRMS752XXXXXmotor regen curve

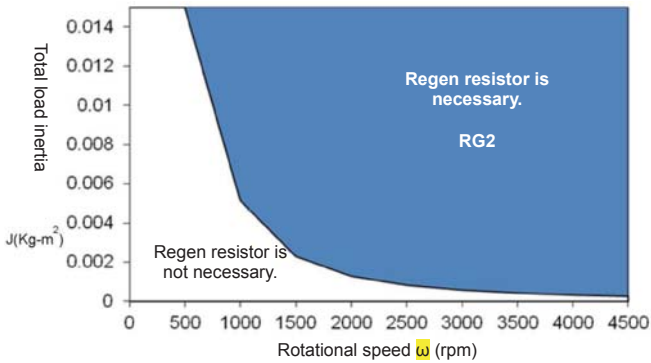


Fig. 7-10 FRMS1K2XXXXXmotor regen curve

Table 7-6 shows the model number of suitable regen resistors for each D2 drive. Table 7-7 shows the model number of regen resistors for HIWIN products. Users can choose to use series or parallel connection based on their needs. Table 7-8 and Fig. 7-11 show the appearance and size.

Table 7-6

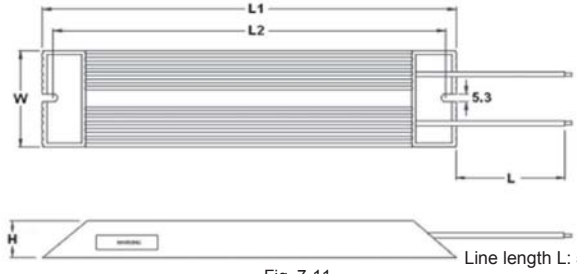
D2 drive model no.	Regen resistor model no.
A frame	-
B frame	RG1
C frame	RG2

Table 7-7

Regen resistor model no.	Resistance value	Rated power/instantaneous power
RG1	68Q.	100W/500W
RG2	120Q.	300W/1500W

Table 7-8

Regen resistor model no.	L1	L2	W	H
RG1	165±2mm	150±2mm	40±0.5mm	20±0.5mm
RG2	215±2mm	200±2mm	60±0.5mm	30±0.5mm



Line length L: 500mm

Fig. 7-11

8 Applications

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Click on the main page to enter "Application Center" as shown in Fig. 8-1.

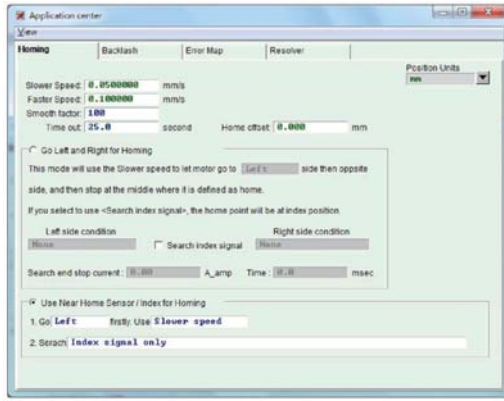

Application center
View
Homing
Backlash
Error Map
Resolver
Position Units
mm
Slower Speed: 0.0500000 mm/s
Faster Speed: 0.100000 mm/s
Smooth factor: 100
Time out: 25.0 second
Home offset: 0.000 mm
Go Left and Right for Homing
This mode will use the Slower speed to let motor go to Left side then oppsite
side, and then stop at the middle where it is defined as home.
If you select to use <Search index signal>, the home point will be at index position
Left side condition
Right side condition
None
Search index signal
None
Search end stop current: 0.00 A_amp Time: 0.0 msec
Use Near Home Sensor / Index for Homing
1. Go Left firstly Use Slower speed
2. Serach Index signal only

Fig. 8-1 Application Center

8.1 Homing settings

The first tab in the Application Center is the "Homing" setting page (Fig. 8-2 Homing settings).

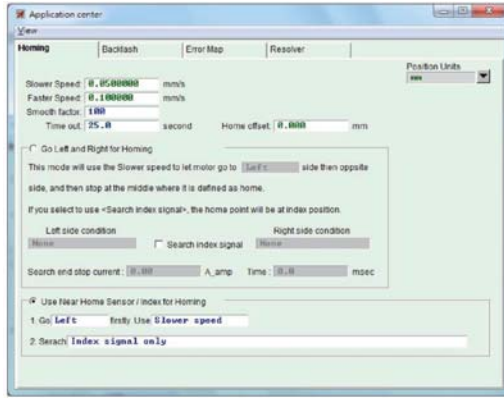

Application center
View
Homing
Backlash
Error Map
Resolver
Position Units
Slower Speed: 0.050000 mm/s
Faster Speed: 0.100000 mm/s
Smooth factor: 100
Time out: 25.0 second
Home offset: 0.000 mm
Go Left and Right for Homing
This mode will use the Slower speed to let motor go to Left side then opposite
side, and then stop at the middle where it is defined as home.
If you select to use <Search index signal>, the home point will be at index position.
Left side condition
Right side condition
Search index signal
Search end stop current: 0.00 A_amp Time: 0.0 msec
Use Near Home Sensor / Index for Homing
1. Go Left firstly Use Slower speed
2. Serach Index signal only

Fig. 8-2 Homing settings

There are 5 basic parameter settings for homing:

Fig. 8-3

Parameter name	Description
Slower Speed	Slow homing velocity
Faster Speed	Fast homing velocity
Smooth factor	The smooth parameter range between 1 and 500.
Timeout	Time out
Home offset	Home offset

There are 2 homing modes:

1. Determining the home by searching the left and right side conditions: Refer to 8.1.1 for more information.
2. Determining the home by searching the Near Home Sensor or the index signal of encoders. Refer to 8.1.2 for more information.

After completing the setting of homing mode, you can click the "Home" button at the bottom of the "Performance Center" page to activate the homing procedure. The "Homed" status indicator on the Performance Center page flashes green when homing is proceeding and the Homed status indicator lights green when homing is completed (Fig. 8-4). If no homes are found before Time Out, the "Homed" status indicator lights red, meaning homing fails (Fig. 8-5).

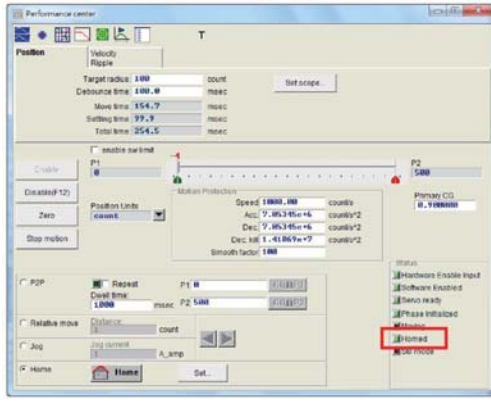


Fig. 8-4 Homing succeeds

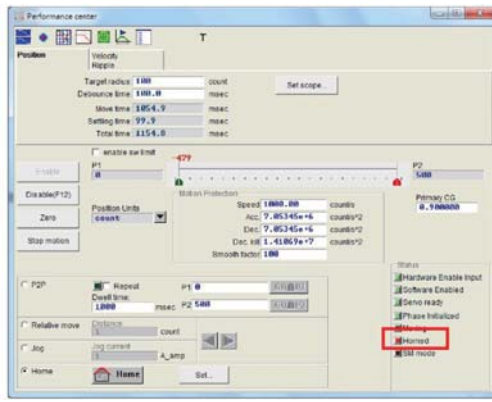


Fig. 8-5 Homing fails

8.1.1 Determine home by searching the left and right side conditions

This is a built-in multi-functional homing mode in the D2 drive. The home position is determined by searching the left and right side conditions. The midpoint between the two boundaries is the home. Users can choose the Left, Right Limit Switch on the IO Set/test page or search the End Stop that is search left and right side conditions through the current generated by motor touches the mechanic stop. If you want to search the single index in the stroke and define it as the home, check the Search Index Signal.

Homing in this mode is described as follows:
The motor will move at the slow homing velocity in the initial motion direction set at the beginning (parameter ①). For example, assume that parameter ① is Left, the motor will search the left side first and then the right side, and stop at the middle point will be considered as the home of both sides. If users checks the Search Index Signal, the index, closest to the left side condition in the motion, will be set the home. The searching conditions of left and right side are determined by the settings (parameter ② and parameter ③).

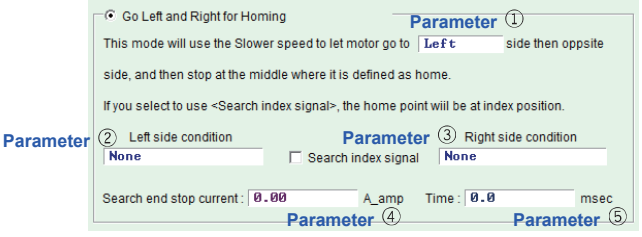

Go Left and Right for Homing
Parameter ①
This mode will use the Slower speed to let motor go to Left side then oppsite
side, and then stop at the middle where it is defined as home.
If you select to use <Search index signal>, the home point will be at index position.
Parameter
② Left side condition
None
Parameter ③ Right side condition
Search index signal
None
Search end stop current : 0.00 A_amp Time : 0.0 msec
Parameter ④
Parameter ⑤

Fig. 8-6 Determine home by searching the left and right side conditions

Table 8-1

Parameter no.	Setting parameters	Options	Description
①	Initial motion direction	Left	Search the left side first
		Right	search the right side first
②	Left side condition (Left side condition)	None	Not to use the left side condition
		End Stop	Search the End Stop on the left side
		Left Limit Switch	Search the limit switch on the left side
③	Right side condition (Right side condition)	None	Not to use the right side condition
		End Stop	Search the End Stop on the right side
		Right Limit Switch	Search the limit switch on the right side
④	Current of searching End Stop		
⑤	Time parameter End Stop (Time)		

Select one of the following for the left or right side conditions..
1. None: Non-search
2. End Stop: Search the End Stop
3. Limit Switch: Search the limit switch

To Search End Stop should be carried out with parameter ④and parameter ⑤. Parameter ④is used to set the force needed for searching the End Stop and parameter ⑤is to set the time for the force. If the time is too short, an End Stop may be mistaken before it is found. If the time is too long, the force pressing the End Stop will increase, or it well reach the soft-thermal threshold. You can search the current of End Stop by following the steps below.

Step 1. Turn on the graphical oscilloscope (Fig. 8-7 graphical oscilloscope) and observe the physical of the Actual Current diagram.
Step 2. Use the slower Speed to move all strokes.
Step 3. Observe the change in the Actual Current diagram and record the maximum value. In the figure below, the maximum value is about 0.2A; therefore, the current of searching End Stop can be set to be slightly more than 0.2A (0.23A in this case).

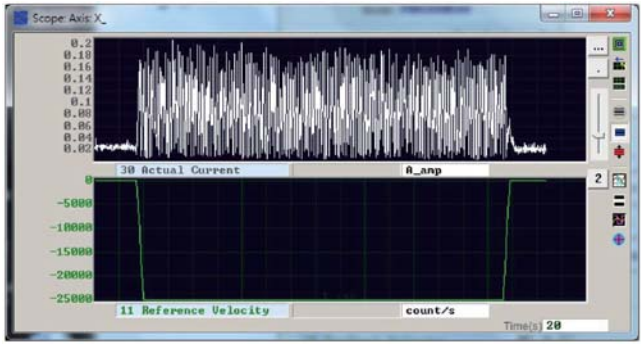


Fig. 8-7 Graphical oscilloscope

Exception:
When the Left Side Condition is set to None (i.e., not to use the left side condition), the Right Side Condition is set to End Stop or Right Limit Switch and the initial motion direction (parameter ①) is set to left, it will be determined that homing fails and the Homed status indicator will light red (Fig. 8-8) in homing and vice versa.

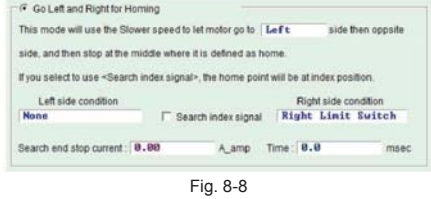

Go Left and Right for Homing
This mode will use the Slower speed to let motor go to Left side then oppsite side, and then stop at the middle where it is defined as home.
If you select to use <Search index signal>, the home point will be at index position.
Left side condition
Right side condition
None
Search index signal
Right Limit Switch
Search end stop current : 0.00 A_amp Time : 0.0 msec

Fig. 8-8

If users checks Search Index Signal but there are multiple indexes in strokes (e.g., the Z-phase signal of the AC encoder of servo motor), the drive will choose the index closest to End Stop or Right Limit Switch as the home.

The Homing example:
In the settings of Fig. 8-9, the motor will move at the slow homing velocity in the negative direction to search the Left Limit Switch and search the first Z-phase index signal at the slow homing velocity in the positive direction when the homing procedure begins. Refer to 8-10 for action process.

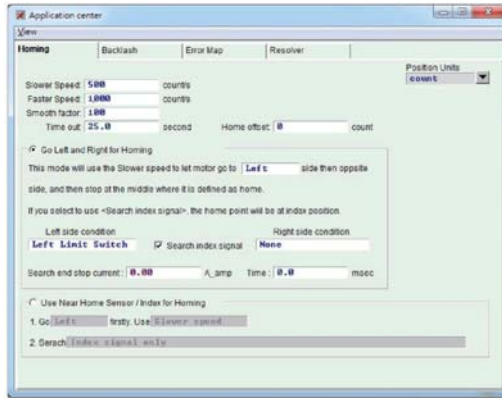

Application center
View
Homing
Backlash
Error Map
Resolver
Position Units
count
Slower Speed: 500 counts
Faster Speed: 1000 counts
Smooth factor: 100
Time out: 25.0 second
Home offset: 0 count
Go Left and Right for Homing
This mode will use the Slower speed to let motor go to Left side then oppsite
side, and then stop at the middle where it is defined as home.
If you select to use <Search index signal>, the home point will be at index position
Left side condition
Left Limit Switch
Search index signal
Right side condition
None
Search end stop current: 0.00 A_amp Time: 0.0 msec
Use Near Home Sensor / Index for Homing
1. Go Left firstly. Use Slower speed
2. Serach Index signal only

Fig. 8-9

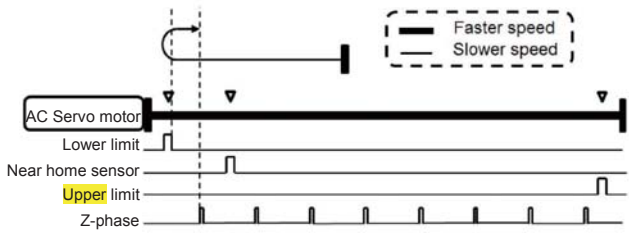


Fig. 8-10

8.1.2 Searching Near Home Sensor or encoder index signals

Another multi-functional homing method is to search the Near Home Sensor or the index signal of encoders. The Near Home Sensor can be set on the IO set/test page to digital input that allows the sensor to be triggered by an external switch. After completing the search of Near Home Sensor, users can search the index signal of encoders on left or right sides for better accuracy.

Homing action is described as follows:
The motor will move in the setting initial motion direction (parameter ⑥) at the initial motion velocity (parameter ⑦) to search the Near Home Sensor or the index.

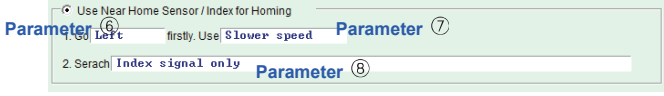


Fig. 8-11

Table 8-2

Parameter no.	Setting parameters	Options	Description
⑥	Initial motion direction	Left	Set to search the left side first
		Right	Set to search the right side first
⑦	Initial motion velocity	Slower speed	Search at the low homing velocity. Set the velocity in the Slower Speed area (Fig. 4-36)
		Faster speed	Search at the fast homing velocity. Set the velocity in the faster Speed area (Fig. 4-36)
⑧	Searching homes method	Index signal only	Search the index signal of encoders only
		Near Home Sensor only	Search the Near Home Sensor only
		Near Home Sensor then change to lower speed, move left, search index	After the Near Home Sensor is found, switch to search the index signal of encoders on the left side at low homing velocity.
		Near Home Sensor then change to lower speed, move right, search index	After the Near Home Sensor is found, switch to search the index signal of encoders on the right side at low homing velocity.

If user uses the Near Home Sensor for homing, Please connect the photoelectric and mechanical switches to the digital input of the drive. For example, set I2 to the Near Home Sensor on the IO set/test page as shown in Fig. 8-12.

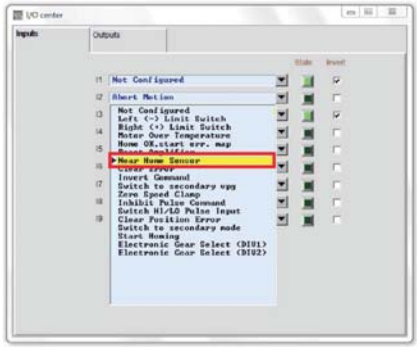


Fig. 8-12

The Homing example:
In the settings of Fig. 8-13, the motor will move at the fast homing velocity in the negative direction to search the Near Home Sensor and search the first Z-phase index signal at the slow homing velocity in the negative direction when the homing procedure begins. Refer to Fig. 8-14 for the action process.

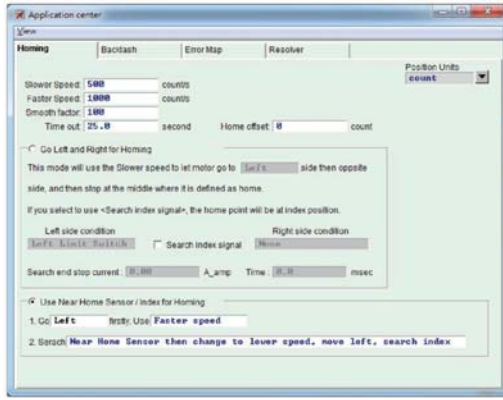

Application center
View
Homing
Backlash
Error Map
Resolver
Position Units
count
Slower Speed: 500 counts
Faster Speed: 1000 counts
Smooth factor: 100
Time out: 25.0 second
Home offset: 0 count
Go Left and Right for Homing
This mode will use the Slower speed to let motor go to Left side then opposite side, and then stop at the middle where it is defined as home.
If you select to use <Search index signal>, the home point will be at index position.
Left side condition
Left Limit Switch
Search index signal
Right side condition
None
Search end stop current: 0.00 A_amp Time: 0.0 msec
Use Near Home Sensor / Index for Homing
1. Go Left firstly. Use Faster speed
2. Serach Near Home Sensor then change to lower speed, move left, search index

Fig. 8-13

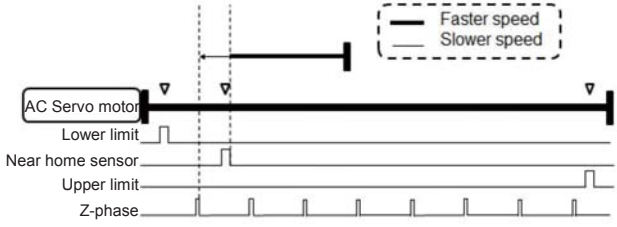


Fig. 8-14

8.1.3 Home Offset

If the Home Offset is set to a non-zero value, a new home will be set by being moved from the original home by a distance. Take the left and right side conditions are not set to None, the drive will move the original home by a distance to become the new home (Fig. 8-15). If the Home Offset value is positive, the new home will be on the right side of the original home. If the Home Offset value is negative, the new home will be on the left side of the original home..

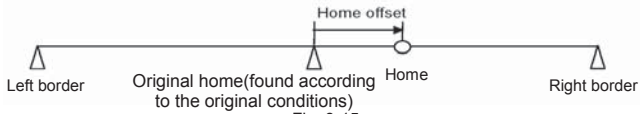


Fig. 8-15

8.2 Backlash compensation

The backlash error is a platform that moves along a fixed axis and stops, and when it begins to move in the opposite direction, the platform does not move immediately but stays in the same position and waits for the motion command to accumulate to a certain degrees.

The setting page is shown on the "Backlash" tab. As it is shown, the backlash compensation setting can be used for backlash compensation to improve bidirectional repeatability.

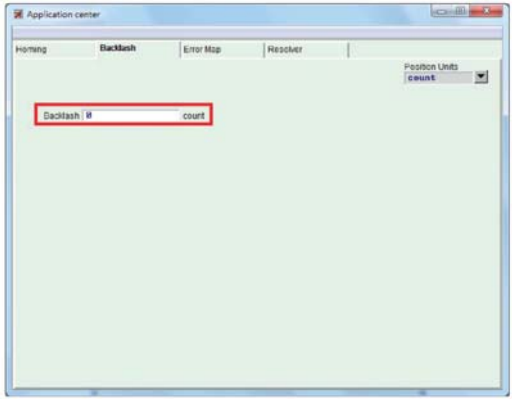


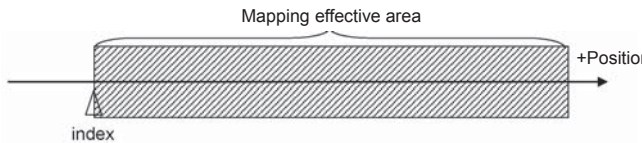
Fig. 8-16 Backlash compensation settings

Backlash setting method: Enter the measured backlash value in the settings to complete the backlash compensation setting.

8.3 Error Map

A systematic error in the machinery often exists in the positioning system of the AC servo motor driving screw. A laser interferometer is generally used to measure the positioning accuracy. The positioning error table obtained from the measurement coupled with Error Map can improve the accuracy. The error table is entered to the drive via the HMI input and save. The drive applies the information in motion to calculate the error value through the linear interpolation in certain distances in order to improve the positioning accuracy. When using the laser interferometer in measurement, users can use the integer multiple of the screw pitch as the sampling distance of laser measurement to measure the error value of every stop point and obtain the systematic error of screws. The values will be entered to the drive for the improvement of accuracy. After obtaining the error table from the positioning accuracy measurement, you should set the Interval and Total Points and enter the Error Map value to the table one by one. The effective range of the Error Map table is divided by index. The area in the positive direction of the index is mapped while the area in the negative direction of the index is not mapped. The effective range when users uses the non-zero Home Offset zero Home Offset are the same. Refer to the figure below. Refer to the figure below. The mapping effective area when Home Offset is set to 0.

When Home Offset is set to 0



Drive coordinate =0

When Home Offset is set to 100

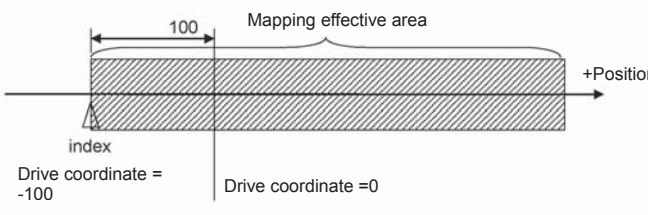
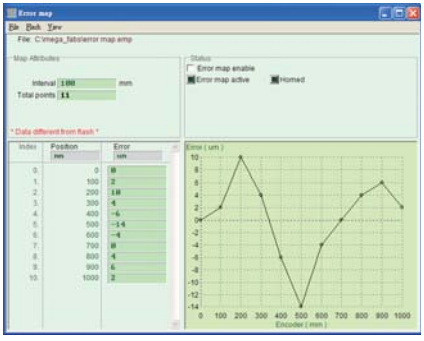
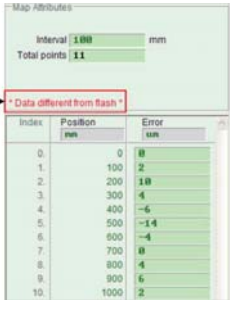
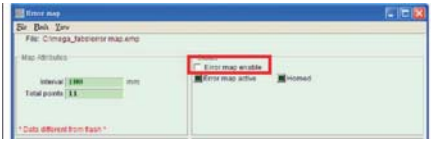


Fig. 8-17

8.3.1 Operation of Error Map

The steps to activate D2 drive Error Map are described as follows:

Step	Graphical (HM) description	Operation
1		Click in the main function area or click the Error map option in the Setting/Adjustment (Conf/Tune) on the function menu to open the window as shown in the left figure.
2	Reminder that the revised mapping value has not been saved to the drive Flash 	Set the Interval and Total points. If you have a preferred unit system, click the field below Position to set the suitable unit. Then enter the Error Map value to the Error table.

3		Check Error map enable to activate the Error Map.
4		The drive has the general servo parameter and Error Map parameter. Click "Send table to flash" in Flash on the function menu. If the general servo parameter was revised but not saved to Flash, the window will show a reminder (left figure). It is suggested that users should click Cancel to return to the main screen, and save the general servo parameter to Flash. After general servo parameter is saved, the Error Map parameter.
5	Same as above	If clicked Continue in the above-mentioned step, the drive will force it to Reset and save the Error Map parameter. Yet, the revision on the general servo parameter will lost.
6		The confirm window appears. Click "Confirm" to save the Error Map parameter to Flash and the drive will automatically Reset.

Step 2. notes

The example additional remarks in the manual. The mapping range is between 0~1000mm. The interval is 100mm and the total points are 11. The value in the Error field (Fig. 8-18) comes from the error measurement of laser interferometer. Every value stands for the positioning error (Error) of every target position. For example, if the target position is 100mm and the laser measurement report 100.002mm, then enter the 2um for error value.

Error Map screen description

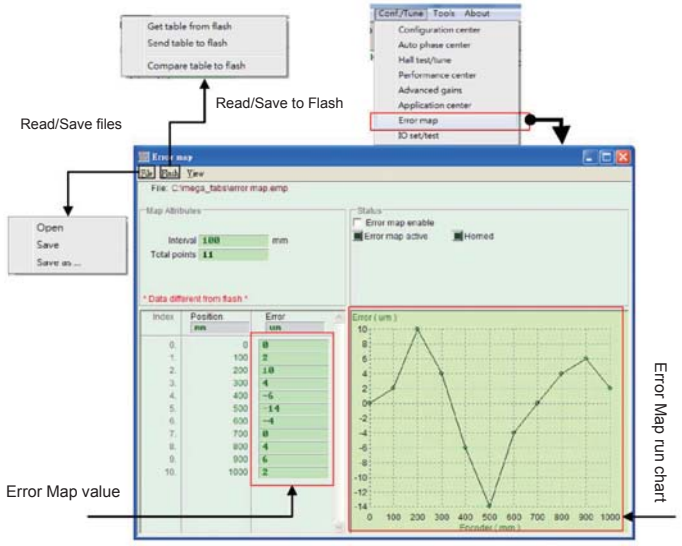


Fig. 8-18

8.3.2 Activation of Error Map

After completing setting the aforesaid Error Map parameter will have the ability to Error Map, the drive as long as motor homing is completed, drive activates Error Map immediately. There are two ways for the D2 drive to complete homing.

Homing in conjunction with the host controller
First, Set the Home OK and Start err. map input functions at I/O Set/test(Fig. 8-19). Take I2 input in the following figure is an example. The setting is shown in Fig. 8-19. After the host controller sends the motion commands to the drive via the pulse or voltage commands to move the motor to the home and stop motion. The host controller should send signals to I2 via the digital control output. If the drive receives the signal, which means homing is completed and Error Map is activated.

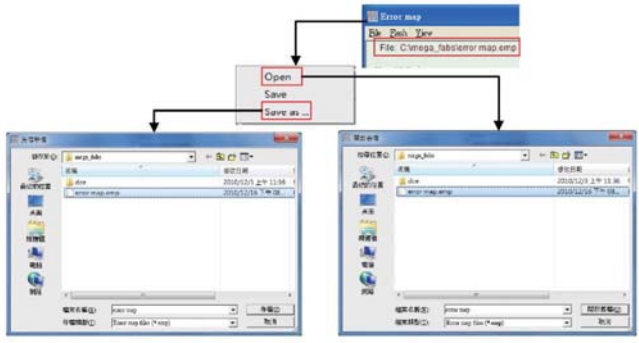
Fig. 8-19 Host controller sending signals to notify of homing completion and Activation of Error Map

Stand-Alone homing
Open the Performance Center window to run homing Home. After homing is completed, the Error Map will be activated automatically.

How to confirm whether the Error Map is activated
Any time users wants to confirm whether Error Map is active, they can observe whether the Error Map Active (Error map active) on the Error Map window lights green which status at means Error Map is active.

8.3.3 Save and read the error table file

The established error map value can be saved to the disk, and read directly from the disk also. Click "File" on the tool bar in the following figure to access. As mentioned in 8.3.1, the "Send Table to Flash" in Flash on the function menu can be used to save the map table to the flash memory of the drive. Please pay attention to the “Save the Flash” button on the main screen, the map table mentioned in this section will not



8.3.4 Error Map value and encoder resolution

When the Error Map value is entered to the table, the value will be rounded up or down to integer or its multiple of the encoder resolution. For example, if the encoder resolution is 2μm and the entered error value is 1μm, the program will forcibly convert.

9 Troubleshooting

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9.1 Status indicators of the drive

The status indicator of the drive is a LED lamp on the front panel to display the current status of the drive. The statuses are described in the table below:

→ Status indicator

Status indicator	**Status of the drive**
Off	The drive is not connected to the power source.
Both red and green lamps flash	The drive is booting.
Flash green	The motor is not powered.
Light green	The motor is active.
Flash green and light red	The motor is not powered and an error occurs.

Note: The status indicators look orange when both the red and green are on.

Fig. 9-1

9.2 Errors and warnings of the drive

9.2.1 Status display area on Lightening HMI main screen

When an error is identified, the D2 drive will activate the protection mechanism and display the description of the last error in the "Last error" area (Fig. 9-2). Users can use this description to adjust and confirm the error of the drive. When any incident which needs to be warned occurs during the operation, the drive will display the incident in the "Last warning" area.

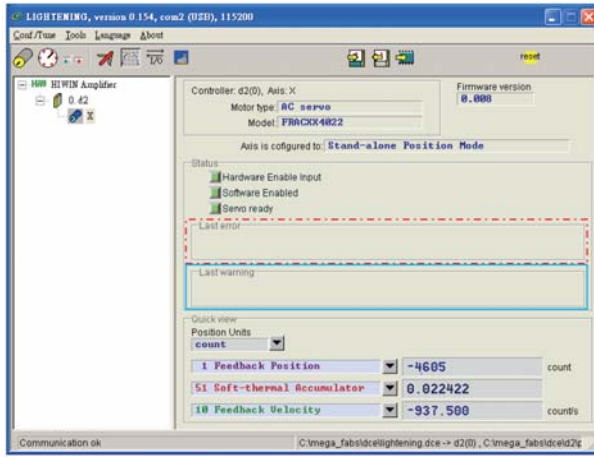

Fig. 9-2 Status display area of the drive

9.2.2 LCD status

The servo status is displayed in the first line on the home page of the panel (Fig. 9-3).
SV NORDY: Servo disabled, servo Off, motor is not powered
SV RDY: Servo enabled, servo On, motor is powered
The error or warning code is displayed in the second line on the homepage when an error or warning occurs.

For LCD error codes, refer to 9.3 and 9.4 about the error/warning codes and solutions.

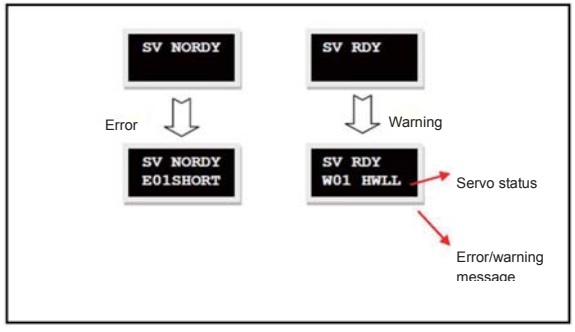

Fig. 9-3

9.2.3 Error and warning logs

When D2 drive detects the identified error or warning, it will store them in the Errors and Warnings Log in addition to displaying in the error/warning status display area on the main screen (Fig. 9-2). The steps to open the Errors and Warnings Log window is shown in Fig. 9-4.

Lightening provides this function to prevent the displayed error or warning message that the D2 drive reports from being lost by users. All errors and warnings messages occurring after the drive is powered and the number of the occurrences are recorded in the Errors and Warnings Log.

The Time Log of the Errors and Warnings Log is shown in Fig. 9-5. The messages of all error and warning that have happened to the drive are recorded in the "Type of error/warning" column, and the time of each occurrence is recorded in the "Time (seconds)" column.

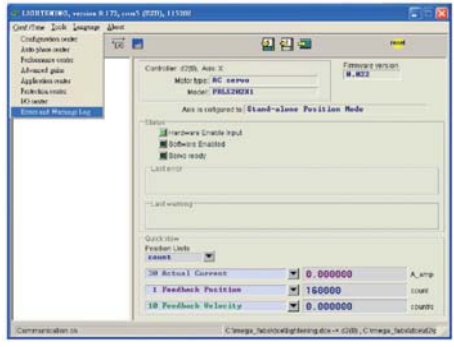

Fig. 9-4 Open the Errors and Warnings Log

Fig. 9-5 Errors and Warnings Log

The Statistics of the Errors and Warnings Log is shown in Fig. 9-6. The number of the errors or warnings (Frequency) that have happened to the drive are recorded in this window. With this information, users can understand the errors or warnings that happened most frequently and take appropriate actions.

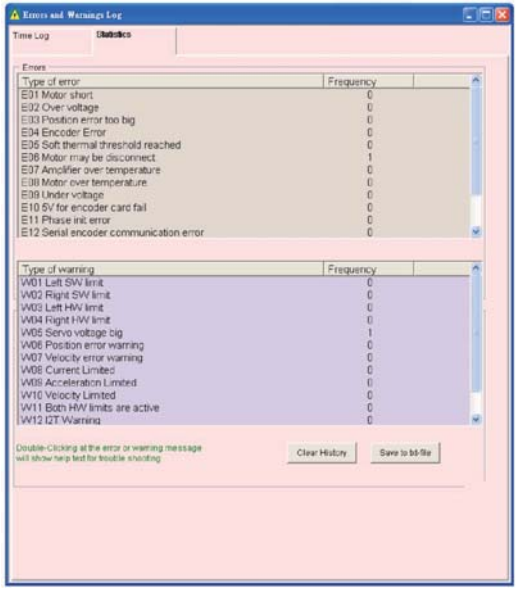
Errors and Warnings Log
Time Log
Statistics
Errors
Type of error
Frequency
E01 Motor short 0
E02 Over voltage 0
E03 Position error too big 0
E04 Encoder Error 0
E05 Soft thermal threshold reached 0
E06 Motor may be disconnect 1
E07 Amplifier over temperature 0
E08 Motor over temperature 0
E09 Under voltage 0
E10 5V for encoder card fail 0
E11 Phase init error 0
E12 Serial encoder communication error 0
Type of warning
Frequency
W01 Left SW limit 0
W02 Right SW limit 0
W03 Left HW limit 0
W04 Right HW limit 0
W05 Servo voltage big 1
W06 Position error warning 0
W07 Velocity error warning 0
W08 Current Limited 0
W09 Acceleration Limited 0
W10 Velocity Limited 0
W11 Both HW limits are active 0
W12 I2T Warning 0
Double-Clicking at the error or warning message will show help text for trouble shooting
Clear History
Save to txt-file

Fig. 9-6 Statistics of the Errors and Warnings Log

Users can double click the type name of an error or warning to show “Help tips” dialog box (Fig. 9-7) and view the contents of the message. In this example, click “E06 Motor may be disconnected” to open the dialog box and read the possible cause and solution for the error.

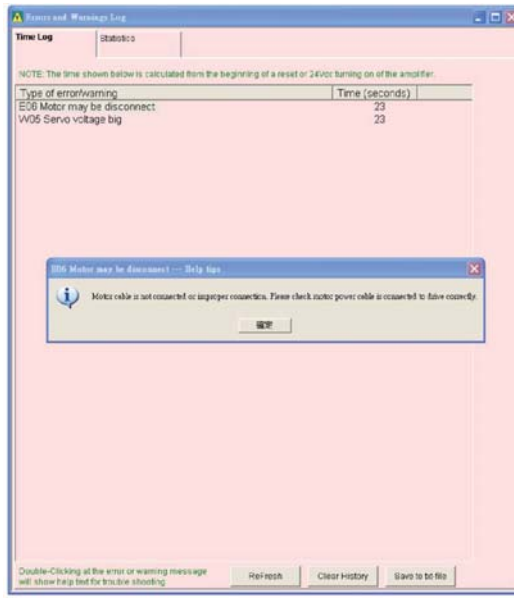
Errors and Warnings Log
Time Log
Statistics
NOTE: The time shown below is calculated from the beginning of a reset or 24Vdc turning on of the amplifier.
Type of error/warning
Time (seconds)
E06 Motor may be disconnect
23
W05 Servo voltage big
23
E06 Motor may be disconnect --- Help tips
Motor cable is not connected or improper connection. Please check motor power cable is connected to drive correctly.
確定
Double-Clicking at the error or warning message will show help text for trouble shooting
Re-Fresh
Clear History
Save to txt file

Fig. 9-7 Help tips window of the Errors and Warnings Log

9.3 Error codes and actions

No.	Errors	LCD error codes	Actions
1	Motor short (over current) detected	E01 SHORT	A three-phase short circuit is detected. 1. Disconnect the drive, remove the UVW connector at the drive end and check whether the short circuit happens between the UVW and ground. The motor might be burned out if short circuit occurs. 2. Measure the motor UVW resistance to make sure it is close to the specifications. The motor might be burned out if this resistance is much lower than the specifications. 3 .Separate the motor from the motor wire and use a multimeter to check the motor wire for shirt circuit.
2	Over voltage detected	E02 OVERV	The voltage of the DC bus in the drive is too high. 1. When the motor sustains a high load and operates at a high speed, this error may occur if the back electromotive force exceeds the voltage limit. A regen resistor can be used to solve this problem and the selected regen resistor must conform to the load and motion specifications.
3	Position error too big	E03 PEBIG	The position error is bigger than the maximum pos error value defined in the Motion Protection. 1. The gain is tuned inappropriately. 2. Confirm that Application center->Protection-> ->maximum pos error is set appropriately. Refer to 9.3.1 for more information. 3. The motion of the motor is obstructed. 4. Check the position feedback reader and make sure it displays normally. 5. Check the linear scale and make sure it is clean. 6. Check if the load is too high. 7. The guideway has not been maintained for a long time. 8. The cable trays are too tight. 9. W05 SVBIG happens continuously before E03 occurs.
4	Encoder error	E04 ENCOD	Encoder signal error. 1. Digital encoder - AB phase sequence error. 2. Analog encoder - The sinusoidal signal is too low when the motor is not in motion. 1. When a Renishaw optical position feedback device is used, make sure that the reader lights green. If not, check if the 5V power and signal cables are loose or in a short circuit state. If the reader lights red, adjust the reader gap of the encoder. Make sure that the scale is clean and all connectors of the encoder are connected firmly. Check that the encoder is wired correctly. 2. The error may be brought about by external interference if a digital encoder is used. Check that the encoder has an anti-interference twisted wire and shield or is equipped with an iron core. 3. For the analog encoder that sustains a low load, use the software to search the motor angle. Signal attenuation might occur if the initial phase frequency is too high. In this case, reduce the initial phase frequency by lowering the current of SW1 or SW5.

No.	Errors	LCD error codes	Actions
5	Soft-thermal threshold reached	E05 SWHOT	The motor is overloaded. (The software detects over-temperature of the motor.)
			1. Confirm that the continuous current and peak current of the motor conforms to the specifications of the motor during the motion. 2. The motion of the motor is obstructed. 3. This error can be eliminated by resetting and re-enabling the drive, but it may recur if the current output exceeds the specified value due to load and motion parameter settings. 4. Reduce the speed, acceleration or deceleration. 5. The model number or current parameter of the motor is set incorrectly.
6	Motor may be disconnected	E06 UVWCN	1. The power line of the motor is not connected to the drive correctly.
			1. Check that the UVW power line connector is connected firmly. 2. Check that the model number of the motor is set correctly.
7	Amplifier over temperature	E07 D.HOT	The drive sustains over-temperature.
			1. Check that the position where the drive is installed is well ventilated. 2. Check that the ambient temperature is not too high. 3. Wait for reduction of the temperature inside the drive. 4. The error may be brought about by the high load or frequent operation cycle of the drive. A cooling fin can be mounted if needed.
8	Under voltage detected	E09 UND.V	The voltage of the DC bus in the drive is too low.
			Confirm that the drive (L1, L2) is connected to a 100 or 220Vac power source. Use a multimeter to make sure that there is a 100 or 220Vac power input.
9	5V for encoder card fail	E10 V5ERR	The 5V power supply for the encoder card is abnormal.
			1. Remove the CN2 and CN3 connection of D1 or remove the CN6 and CN7 connection of D2 as well as the power line connector of the motor. Confirm whether E10V5ERR still occurs. If yes, please contact the manufacturer to repair and check. If not, please check if short circuit happens and modify the wiring. 2. If applicable, do not use the CN2 and CN3 connection of the hot-plugging D1 or the CN6 and CN7 connection of D2.
10	Phase initialization error	E11 PHINI	Initialization of the motor fails. The trunk line of a 17-bit encoder is connected to the motor of a 13-bit encoder.
			1. Check that the UVW three-phase motor wire of the drive is connected. 2. Check that the encoder is connected. 3. The phase initialization parameter is not set appropriately. Refer to 9.3.2 for more information about the setting.
11	Serial Encoder Communication Error	E12SER .E	The serial encoder has a communication error.
			1. Check that the encoder is connected. 2. Check that the extended line of the encoder conforms to the specifications of the motor.
12	Hall sensor error	E13 HAL.E	The signal output of the Hall sensor is abnormal.
			1. Check that the encoder is connected correctly.

9.3.1 Supplements to E03 PEBIG error elimination

1. The max. position error can be modified according to the steps as shown in Fig. 9-8.
2. It is not recommended to set the position error higher than the default setting. Adjust the servo stiffness if E03 PEBIG appears with the default setting in use.
3. If no Hall sensor is used and the max. position error is to be modified by searching the motor angle, repeat the startup test to make sure that no E03 PEBIG appears during the search.

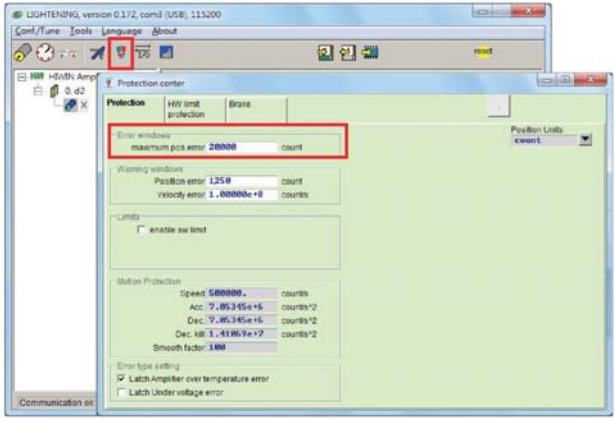

Fig. 9-8

9.3.2 Supplements to E11 PHINI error elimination

If use SW5 to phase initialization, E11PHINI may appear, E11PHINI may appear if the current is not set appropriately. In this case, set the current again with reference to Fig. 9-9.

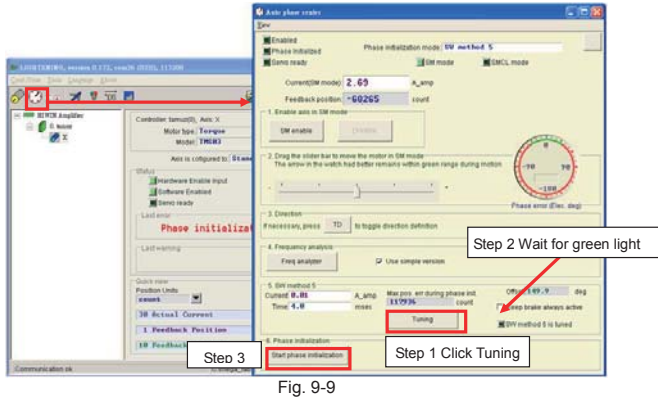

Fig. 9-9

9.4 Warning codes and actions

No.	Errors	LCD error codes	Actions
1	Left SW limit	W01 SWLL	Software left limit is triggered.
2	Right SW limit	W02 SWRL	Software right limit is triggered.
3	Left HW limit	W03 HWLL	Hardware right limit is triggered. If the erroneous triggers occur without any connection from hardware limit to the drive. It is recommended to deactivate the hardware limit enabling the hardware limit enabling state. Refer to 9.4.1 for more information.
4	Right HW limit	W04 HWRL	Hardware right limit is triggered. If there is no connection from the hardware limit to the drive and erroneous triggers may occur, it is recommended to remove the hardware limit enabling state. Refer to 9.4.1 for more information.
5	Servo voltage big	W05 SVBIG	The PWM output switch of the drive has exceeded the limit and the current output cannot be increased any more. The error code E03 PEBIG will show if this warning occurs repeatedly under the position control. 1. Change the power source to 220V if 110V is used currently. 2. Reduce the speed, acceleration or deceleration.
6	Position error warning	W06PE	The position error is greater than the warning setting value.
7	Velocity error warning	W07VE	The velocity error is greater than the warning setting value.
8	Current Limited	W08 CUR.L	The current has been saturated and reached the peak current value of the motor. Repeated occurrence of this warning may bring about E05 SWHOT and power blackout or W12 12T. 1. Reduce the speed, acceleration or deceleration. 2. Reduce the load.
9	Acceleration Limited	W09 ACC.L	The motor has reached the acceleration protection setting value when it operates in the torque or velocity mode. To increase the acceleration, set a higher protection setting value for the acceleration and deceleration. Refer to 9.4.2 for more information.
10	Velocity Limited	W10 VEL.L	The motor has reached the velocity protection setting value when it operates in the torque or velocity mode. To increase the velocity, set a higher protection setting value for the velocity. Refer to 9.4.2 for more information.
11	Both HW limits active	W11 BOTH	Both left and right hardware limits have been triggered. If the erroneous triggers occur without any connection from hardware limit to the drive. It is recommended to deactivate the hardware limit enabling the hardware limit enabling state. Refer to 9.4.1 for more information.

9.4.1 W03 HWLL and W04 HWRL supplementation

If the erroneous triggers occur without any connection from hardware limit to the drive. It is recommended to deactivate the hardware limit function.

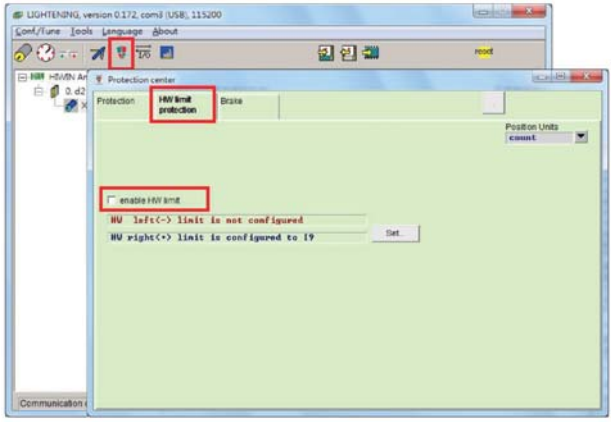

Fig. 9-10

9.4.2 W09 ACC.L and W10VEL.L supplementation

The W09 ACC.L warning message shows and the acceleration is limited if the Acc. and Dec. settings in the Performance Center are less than the command setting. This problem can be solved by increasing the Acc. and Dec. settings. It is recommended to increase the Acc. and Dec. settings to 10 times the current speed.

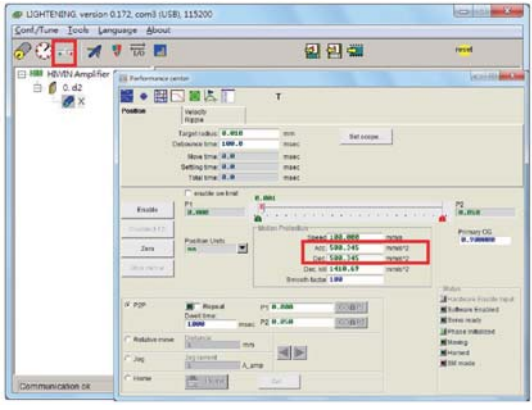

Fig. 9-11

The W10 VEL.L warning message shows and the velocity is limited if the Speed setting in the Performance Center is less than the command setting. This problem can be solved by increasing the Speed setting. For example, W10 VEL.L appears if the required speed is 500mm/s^2 and the Speed setting is 100mm/s^2. This problem can be eliminated by increasing the Speed setting to a value higher than the target value (e.g.600mm/s^2).

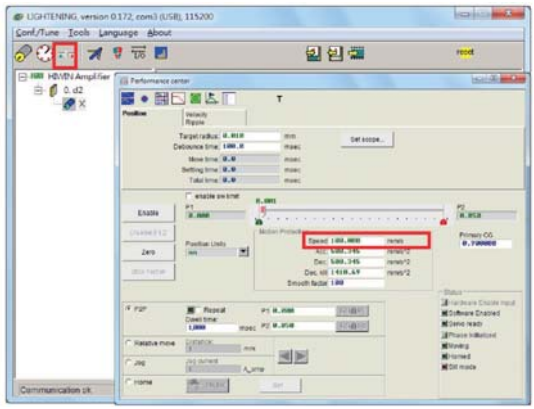

Fig. 9-12

9.5 Troubleshooting of common errors

Serial no.	Situation	LCD code	Actions
1	The speed or acceleration is limited when the motion command is transmitted via the pulse or voltage command. If the motor moves slowly to the destination after the host controller has transmitted all pulse commands for the movement.	W10 VELL W09 ACC.L	Check if the Speed, Acc. and Dec. values in the Motion Protection of the Performance Center are set too low.
2	The motion direction of the motor is opposite to the direction defined by the customer.	None	Method 1. Click TD which is Step 3 in the Auto Phase Center to reset the direction of the motor. Method 2. Check "Invert" in the mode setting.
3	Enable the Error Map.	None	Open the Conf.Tune\Error Map window to confirm the followings: 1. Confirm that the "Error map enable" has been checked. Refer to 8.3.2 for more information. 2. Confirm that the Home action has been performed or homing signal has been set in Input.
4	The motor moves by itself after enabled.	None	1. Use Quick View or Scope to confirm that Target Position has received the input pulse signal. 2. Confirm that the pulse signal cable is not disconnected or no poor contact is identified. 3. Confirm that the signal 0V is connected to the shield or ground. 4. Confirm that the drive and machine are well grounded. 5. A core can be mounted to the pulse cable as a filter, if needed.
5	The motor does not move according to the command after enabled.	None	1. Confirm that the unit is correct. 2. Confirm that the speed or acceleration is set to 0. 3. Confirm whether the SW limit has been enabled. If yes, check that the Upper or Lower limit is set correctly. 4. Push the mover after the motor is disabled and confirm that it moves smoothly.

Serial no.	Situation	LCD code	Actions
6	The pulse has been transmitted but the motor does not operate.	None	1. Use Quick View or Scope to confirm that Target Position has received the input pulse signal. 2. Check whether the pulse cable is connected, disconnected or contacted poorly. 3. Check whether the electronic gear is set to low.
7	The analog voltage (V Command) has been transmitted but the motor does not operate.	None	1. Use Quick View or Scope to check whether the analog command is input successfully. 2. The voltage offset can be set in the Advanced gains->Analog input window.
8	Noise is too loud during the operation	None	1. Reduce the Common Gain value. 2. The filter can be set in the Advanced gains/Filter window.
9	The temperature of the drive is too high.	E07 D.HOT	1. Check that the position where the drive is at well ventilated. 2. Check that the ambient temperature is not too high.
10	The position feedback sensor (reader) transmits an incorrect signal.	E04 ENCOD	1. Check that the drive, machine and shield have been grounded.
11	The voltage of the DC bus is too low.	E09 UND.V	1. Check the drive is connected to a 100 or 240Vac power source or whether the power source is disconnected. 2. Use a multimeter to check whether it is a 110 or 240 Vac power source
12	The voltage of the DC bus is too high.	E02 OVERV	1. Confirm that the speed, acceleration and load conform to the specifications. 2. Check whether a regen resistor is needed for the motor operating at a high speed. The selected regen resistor must conform to the load and motion specifications. 3. Check if the load is too high. 4. Check if the speed is too high.
13	The position error exceeds the maximum position error setting.	E03 PEBIG	1. Check whether the CG value and the maximum position error value are set too low. 2. Motor is obstructed when moving 3. Check if the load is too high.

Serial no.	Situation	LCD code	Actions
14	The motor UVW is in short circuit.	E01 SHORT	1. Solve the UVW short circuit and wiring problems. 2. Solve the UVW and ground short circuit problem. 3. Check the UVW line-line resistance separately and confirm that the resistance is same between lines. 4. Check whether the motor wires are too old.
15	The equivalent current output from the drive exceeds the continuous current limit of the motor.	E05 SWHOT W12 I2T	1. Confirm that the continuous current and peak current of the motor conforms to the specifications of the motor. 2. The acceleration command for the route planning exceeds the rated value of the motor. 3. The motion of the motor is obstructed. 4. The drive is reset and re-enabled. 5. Check if the model number or current parameter of the motor is set incorrectly.
16	The PC cannot communicate with the drive.	None	1. Check that the BPS and Port are set correctly.
17	The host controller receives an incorrect position signal when the emulated encoder function is used.	None	When the D1 drive is set to “use emulated encorder”.Because the emulated encorder output function does not work during operation of the ”save to flash”. function. If the motor moves by different reasons, when operater the “save to flash” function on the main screen. The host controller may lose the position signal.

A. SMCL Tools

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When SW method 1 is selected for the phase initialization mode, SMCL tools can be used to test motor angle search function and adjust the st_cg and st_vpg parameter values to reduce the displacement during the phase initialization. Click Start SMCL to search the motor angle and observe the displacement during the search process based on the physical value and position error (Fig. A-1). The displacement is decreased significantly with a higher st_cg value. However, the system might become unstable in the SM mode if the st_cg value is set too high.

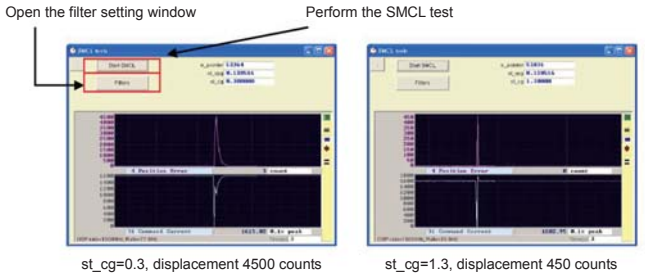

Fig. A-1

A.1 SMCL parameters

st_cg: The proportional gain of the control loop in the SMCL mode. Generally, you could set st_cg value as higher as possible. However, the system might generate resonance and become unstable if the value is set too high. In this case, reduce the st_cg value to the range from 0.2 to 1.5. If the system become stable adequately, st_cg can be adjusted to a value higher than 1.5.

st_vpg: This gain is related to the load of the motor and stands for the no-load gain by default. In the Auto Phase Center, a set of suitable parameters can be generated based on the current load using the auto gain tuning function, and a fine tuning can be performed using the SMCL tools.

A.2 Setting and use of the filter

SMCL tools also provide filters for users. to select. Refer to 6.6.1 for more information about the filters.

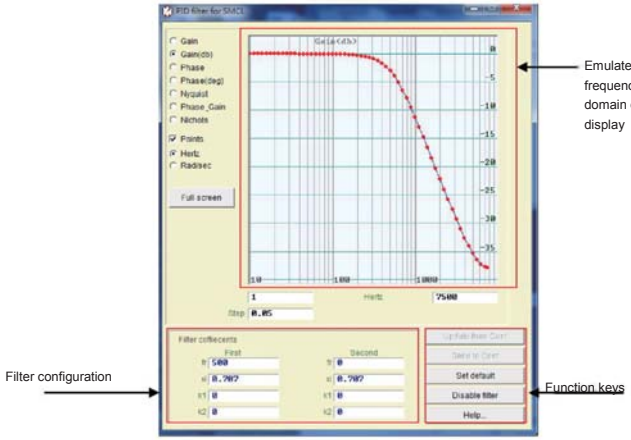

Fig. A-2

B. Axis Enable Setting

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B.1 Axis Enable via the host controller

Usually, the host controller must send a command to the drive via its input port to enable the motor. The Axis Enable function is usually set to the digital input I3 as shown in Fig. B-1.

B.2 Temporary Hardware Enable

If users does not have a host controller and cannot input a Hardware Enable signal to the drive, the Hardware Enable can be provided temporarily after completion of the following settings. Click "IO set/test" in the main function keys area to open the window in Fig. B-1. Confirm that the status indicator of the Axis Enable lights green. I1 is usually used for the Hardware Enable signal. Since the Invert function is available for each input point, it can provide a cheating Hardware Enable signal by inverse the logic value of the signal.. The drive receives a Hardware Enable signal when the indicator in the State column lights green.

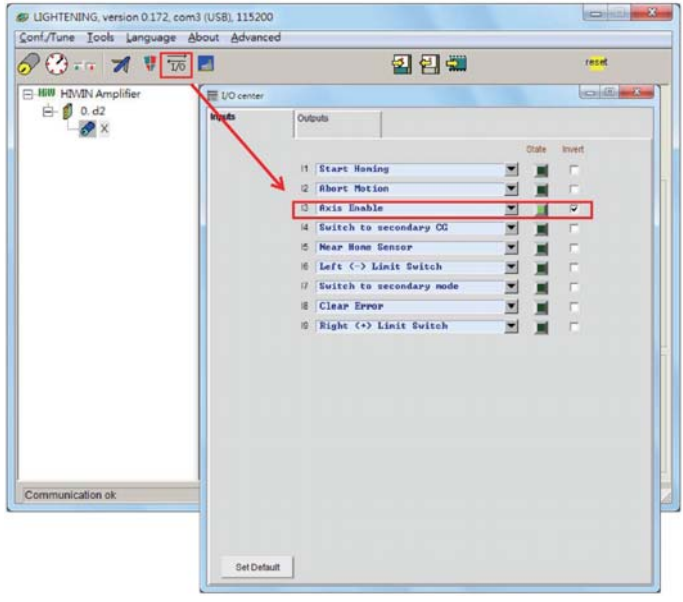

Fig. B-1

B.3 Confirmation of the enabled state

The drive receives the enabling signal from the host controller when the state indictor of the "Hardware Enable Input" lights green (Fig. B-2).

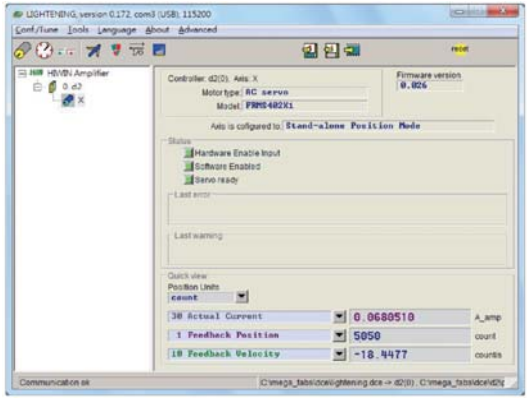

Fig. B-2

B.4 HMI control of Axis Enable

Usually, the Axis Enable signal that the host controller sends through the input port controls the excitation of the motor. The following instructions must be observed when the HMI is opened.

1. When the HMI (Lightening) is the active window on the screen, users can press F12 to disable the motor. This function is usually used in the emergency situation.

2. When the Performance Center is opened from the HMI (Lightening) , users can click the Disable button (same as F12) to disable the motor. Click the Enable button if users needs to enable the motor again. In this case, the status indicator of the Hardware Enable Input must remain green.

C. Parameter Comparison Function

C. Parameter Comparison Function 287
C.1 Compare parameter RAM to flash 288

C.1 Compare parameter RAM to flash

The "Compare parameter RAM to flash" window pops up (Fig. C-1) when users changes the motor parameters in the Lightening program and exits the program before saving them to the flash memory of the drive or when users performs the Error Map and does not save the parameters in the flash memory. (Refer to 8.3.3) .This window is used to remind users that some parameters have been changed and not saved to the flash memory yet.

Compare parameters RAM to FLASH
2 parameters are detected to be changed in RAM from Flash
Press 'Exit' to exit.
Press 'Cancel' to stay,
Consider to do 'save parameters to flash'
Exit
Cancel
Details

Fig. C-1

An advanced comparison window will be opened when users clicks the "Details" button. Users can see the different parameter settings (Fig. C-2 and Fig. C-3) between the RAM and the flash memory in this window. The different parameter is indicated with blue color.

The following two states are displayed in the "Flash value" column:

"=": The value stored in the flash memory is same as that in the RAM.

"∗∗: The parameter has performed Undo and the value in the RAM has been change to a parameter value in the flash memory (Fig. C-3).

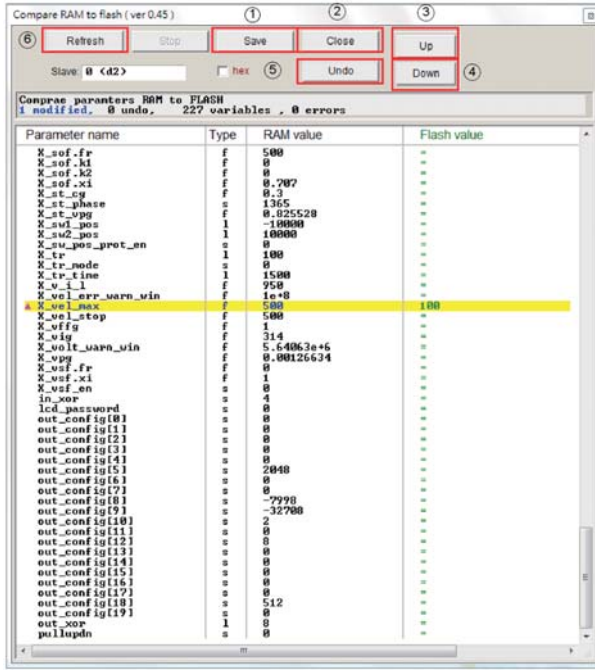

Fig. C-2

The function keys are described below:

① Save: Save the parameter in the flash memory.

② Close: Close the window.

③ Up: Move to the previous different parameter between the RAM and the flash memory.

④ Down: Move to the next different parameter between the RAM and the flash memory.

⑤ Undo: Restore the selected parameter that was stored in the RAM to a value in the flash memory

⑥ Refresh: Re-compare the parameters stored in RAM and the flash memory.

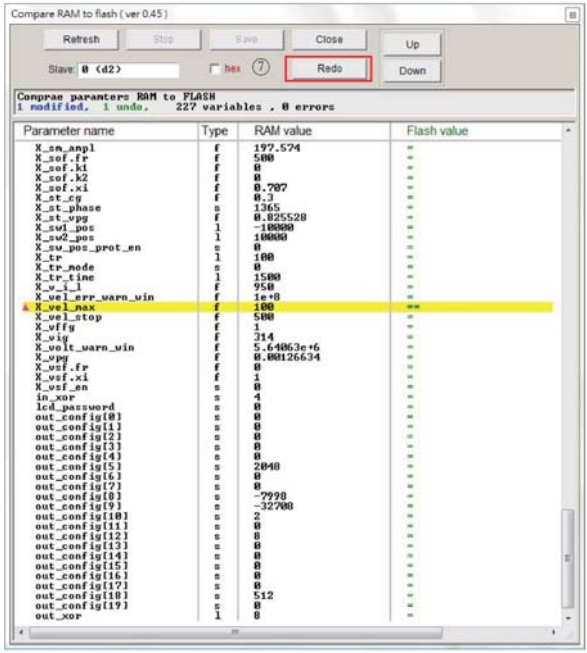

Fig. C-3

⑦ Redo: Cancel the previous Undo action for the selected parameter.

D. How to Update the Firmware of the Drive

D. How to Update the Firmware of the drive 291
D.1 Update the firmware of the drive 292

D.1 Update the firmware of the drive

To update the firmware of the drive, click "Tools" on the main screen and select "Upgrade/Down grade firmware..." (Fig. D-1).Click "Upgrade/Down grade firmware..." to open the "Upgrade/Down grade firmware" window (Fig. D-2).

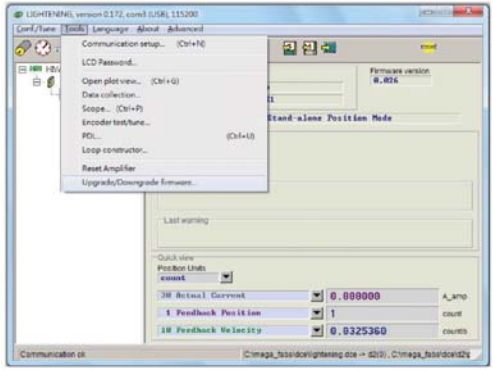

Fig. D-1

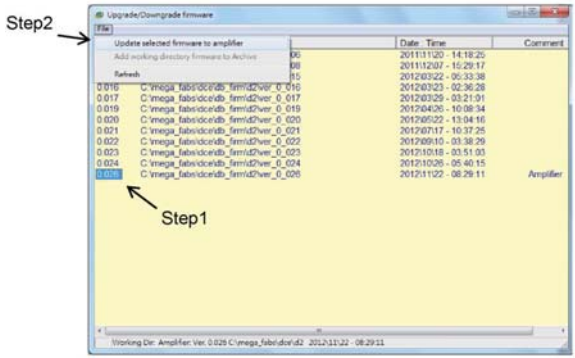

Fig. D-2 Upgrade/Down grade firmware window

The firmware is updated in the Upgrade/Downgrade firmware window according to the following steps.
Left click the firmware version to the updated and highlight it with white letters on a blue background.
Click "File" at the left corner of the window and select "Update selected firmware to amplifier" to open a dialog box (Fig. D-3).
Click OK to open the "Auto load programs" window. The firmware will be loaded in the drive automatically (Fig. D-4).

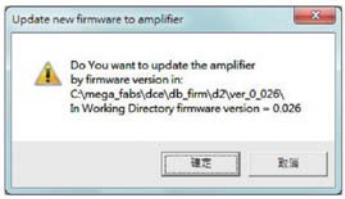

Fig. D-3

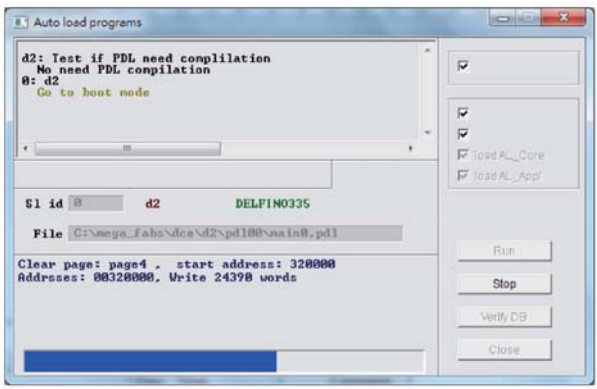

Fig. D-4

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